Co-funded by the COSME programme
of the European Union

CLUSTER MANAGEMENT TOWARDS EXCELLENCE IN ADVANCED MANUFACTURING AND TEXTILE INDUSTRY

Grant Agreement number 872862

Deliverable D1.3: Market studies and value chain growth potential reports

Project acronym:	CLAMTEX
Project full title:	Cluster management towards excellence in Advanced Manufacturing and Textile Industry
Grant agreement no.:	872862
Author(s):	CITEVE
Nature:	Report
Dissemination level:	PUBLIC
Total number of pages:	114114
Version:	1.0
Publication date:	30/09/2021

CLAMTEX has received funding from the European Union's COSME research and innovation programme under grant agreement no. 872862

EXECUTIVE SUMMARY

It is impossible to imagine a world without textiles!

The Textile and Clothing (TC) Sector is an important part of the European manufacturing Industry, playing a crucial role in the economy. According to Euratex, the sector includes approximately 170,000 companies, employing around 1.7 million people (6% share of employment in total manufacturing in Europe) and generating annual exports of €50 billion in a total turnover of nearly €180 billion.

This sector covers a wide range of companies and activities from the transformation of fibres into yarns and fabrics, to the production of an extensive range of products, from the more generic clothing and fashion items to hi-tech applications such as automotive, health or protective equipment, just to give few exemples.

If there is a word for economic resilience, TC for sure is one to remember. This sector has been subject to several challenges over the recent years, from technological changes, production costs reduction and increasing competitiveness from international competitors, to the transformation of the type of production from low value products to high-end products or technical applications with higher value-added.

But there is still a lot to be done where TC Associations, Clusters and Research Organizations can play an important role supporting the European producers to become world leaders in markets for technical textiles as well as for high-quality garments and home textiles with a high design and fashion orientation.

One of the future challenges in the Textile and Clothing industry relies on the capacity to quickly adapt to the industry 4.0 technologies that are changing the state of manufacturing at unprecedented rates, providing several benefits like new levels of scalability, improved management of production, better control of the value chain, and increased customer satisfaction. In this sense, considering the transversal dimension of the Manufacturing technologies and Advanced manufacturing technologies, these can have a decisive role in all the manufacturing driven sectors, namely Textile and Clothing Industry where the machinery and technology play a crucial role in the competitiveness of these industries. Also, further to the productivity benefits arising from Industry 4.0 or Advanced Manufacturing technologies, new opportunities are starting to rise, namely the possibility to customize products for each taste, something that goes against all the mass production concepts where the Textile and Clothing industry operates, or even optimizing energy costs using renewable energy during production spikes, and also creating sustainable fibres with the help of software modelling and artificial intelligence.

Manufacturing is a key enabler for Europe's grand societal challenges!

The European manufacturing industry is aiming at a fundamental impact on 'growth and jobs' which are a prerequisite for social sustainability, addressing the needs of citizens and the environment. Hence 'growth and jobs' are considered to be a major enabler for the achievementof all of the EU's 'grand societal challenges'.

The application of technological innovations in competitively marketable goods and services is enabled by manufacturing. Advanced manufacturing systems play a critical part in making KETs and new products competitive, affordable and accessible, multiplying their societal and economic benefits. Products of high value and superior features cannot generate any value for society and the economy if they are not affordable or if they are late into the market. Advanced manufacturing enables a cost-effective, resource-efficient and timely production and commercialisation.

Manufacturing is also essential for realising all future products related to societal challenges (e.g. energy-related equipment, health products, transport, etc.).

The question is not if Industry 4.0 or Advanced Manufacturing technologies will come for good, but rather, how these technologies will alter the textile industry and the textile production value chain.

CLAMTEX main objective is to strengthen cluster management excellence of the participating European clusters to boost their specialized innovation eco-system by facilitating the cross-sectoral and cross-regional collaboration to facilitate the uptake of digitalization within and beyond the partnership with the implementation of ClusterXchange pilot scheme.

Aligned with the CLAMTEX main objectives, the aim of this study is to provide a comprehensive report on the main characteristics of the sector, present strategic data, and the most relevant trends where the European TC producers can take advantage by fostering collaboration and promoting a transnational innovation ecosystem among enterprises, associations, researchers, experts and C-level managers.

This study starts by presenting relevant economic data on the economic overview of the latest years in the TC and manufacturing industry in Europe; touch basis on the important trend (and opportunity) that is expected to arise from the sustainability and circular economy new order; analysing the global value chains and how the recent pandemic or even new challenges coming from political and social preassure can impact on both Sectores; and finally, evaluating the role of the Custers and Asssociations in the nourishment of the European TC competitiveness, creating conditions for growing new businesses and introduce a more innovation oriented environement in the TC sector.

TABLE OF CONTENTS

INTRODUCTION

The present study aims to identify cross-sectoral trends, opportunities and challenges of the Textile and Advanced Manufacturing Industry, in order to guide the sector's stakeholders, in a context influenced by the COVID-19 pandemic, which emphasized the need to promote Sustainability and Digitalization.

In order to map the path of both sectors in this context, the study adopts an approach based on four essential points.

Firstly, the study makes a characterization of the Textile and Apparel Industry Market and the Advanced Manufacturing Market, in which the trajectory of the sector in the last years, its current state and the main trends in terms of Innovation are identified.

In the second part of the study, the concepts of Sustainability and Circular Economy will be clarified, the main challenges of the sector in this field, the main efforts made to pursue these objectives and the opportunities that can help in this process of transformation.

In the third part, the concepts of Industry 4.0 and Digitalization will be discussed, as well the key technologies related to the Industry 4.0 and the Digitalization process, their adoption and the trends and challenges associated will be adressed.

Then, in the fourth part, textile Industry's global value chain will be described and the main hotspots of the value chain, the technological trends that are reconfiguring the value chain and the opportunities inherent in this reconfiguration process will be identified.

Finally, in the last part o the study, the analysis of the partnership will be conducted, divided into two topics. The first topic consists of a member’s individual analysis that compose the partnership, their aims and objectives, *modus operandi* and contributions of each member to the sector. The second topic is a collective analysis of the cluster, which aims to assess the strengths and weaknesses of the group, in order to identify and maximize potential synergies.

1. GLOBAL MARKET OVERVIEW

1.1 TEXTILE AND CLOTHING MARKET

1.1.1 GLOBAL KEY FACTS AND FIGURES OF BOTH SECTORS (WORLD, EUROPE, SPAIN + FRANCE + PORTUGAL)

The EU Textile Strategy currently under development will highlight the focus investment needed by the European European textiles and clothing (TC) industry to contribute to the objective to achieve a green, digital and resilient EU economy and the more recently emerging needs of the industry triggered by COVID-19.

The textile industry has been going through an accelerated transformation process thanks to technological advancements, changes in production costs, and shifts in global markets. The bulk of textiles and clothing is manufactured in Asia, particularly China, Bangladesh, India, Cambodia, Vietnam, and Turkey. The EU mainly imports finished products from this region. Nevertheless, the EU textile and clothing sector exported €61 bn worth of products in 2019, making the EU the second biggest exporter in the world after China[1].

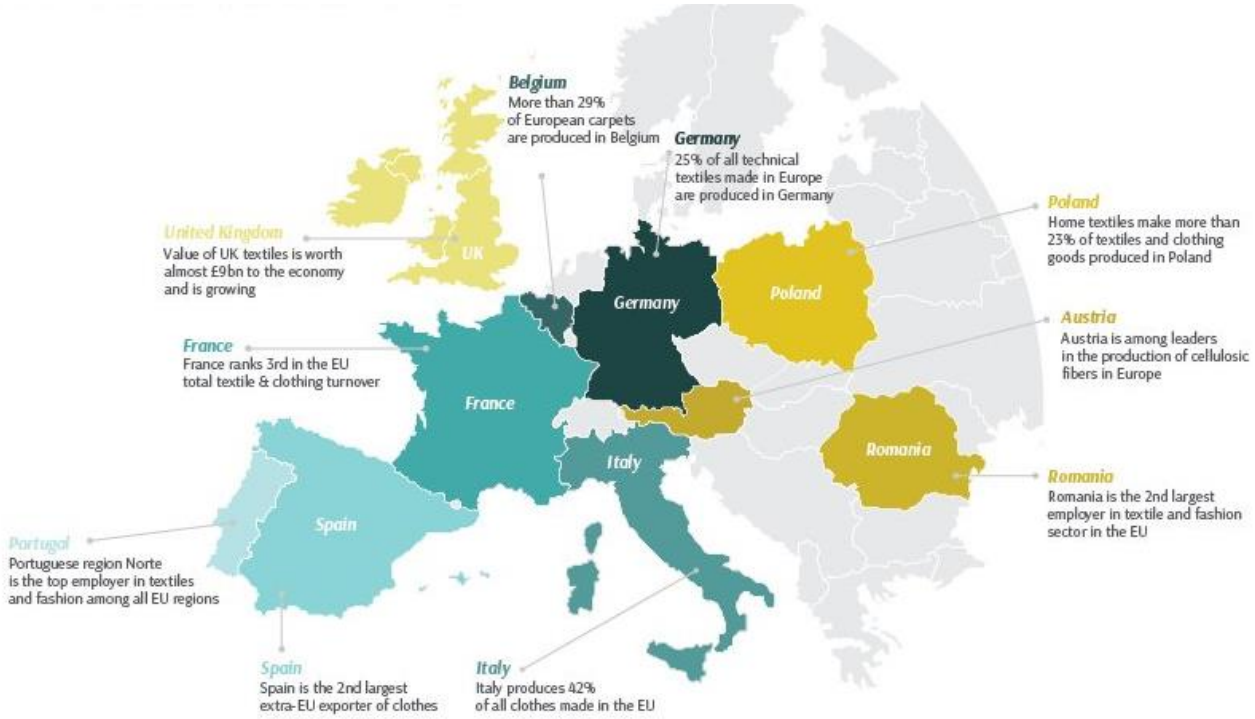


Figure 1 – Top 10 EU Producers of Fashio 1 Top 10 EU Producers of Fashion and Textile Goods: EURATEX, 2020, prospering in a Circular Economy, available at: https://euratex.eu/wp- content/uploads/EURATEX-Prospering-in-the-Circular-Economy-2020.pdf

[1] EURATEX, 2020, Facts and key figures of the European textile and clothing industry, available at: https://EURATEX.eu/wpcontent/uploads/EURATEX-Facts-Key-Figures-2020-LQ.pdf

The European textiles and clothing sector comprises about 170,000 companies (99.8% of which are micro-companies and SMEs) that generate a yearly turnover of almost €180 billion, employing 1.7 million people. The industry experienced a transformation over recent years, through which production of simple, mass consumption items was drastically reduced for the industry to vertically integrate towards higher value-added products such as technical and industrial textiles, including non-woven and high-quality garments and interior textiles with a high design content.

The largest manufacturers in this industry are Italy, Germany, France, and Spain. The top three, Italy, Germany, and France, account for 35%, 14%, and 10% of the EU turnover respectively, with Portugal representing 4%. Clothing manufacturing in EU countries is typically made up of medium-priced and high-end luxury products. EU countries such as Italy, France, and Germany generally produce high-end luxury clothing. With its cheaper labour force, Poland, Hungary, and Romania produce medium-priced products. In the EU27 countries, labour accounted for 21.3% of the total clothing production cost in 2017, up from 19.6% in 2011. Nevertheless, employment in the textile industry has gradually declined over the 2008-2018 period. In 2011, there were 1.606.720 people employed in the textile and wearing clothing manufacturing industry, with this figure decreasing to 1.451.218 in 2018[2].

1.1.2. MARKETS: EVOLUTION, PAST, PRESENT AND FORECASTS

The EU region as a whole remains one of the world's leading producers of textile and clothing. The value of EU's TC production totaled EUR137.3 bn in 2019, down around 2% from a year ago. The EU's TC output value was divided almost equally between textile manufacturing (EUR68.7bn) and clothing manufacturing (EUR68.6bn)[3].

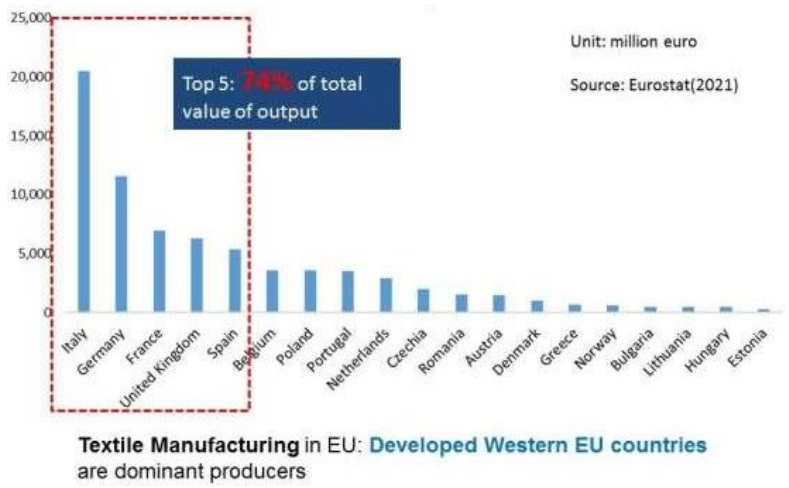
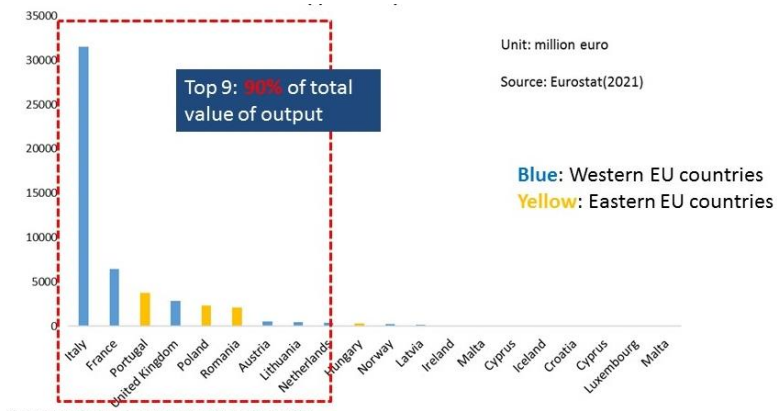


Figure 2 – Value of EU Textile Output in 2019

[2] EASME, 2020, Advanced Technologies for Industry, available at: https://ati.ec.europa.eu/sites/default/files/2021-01/Technological%20trends%20in%20the%20textiles%20industry.pdf

[3] SHENG, Lu, 2021, EU Textile and Apparel Industry and Trade Patterns, available at: https://shenglufashion.com/2021/04/28/eu-textile-and-apparel-industry-and-trade-patterns- updated-april-2021/



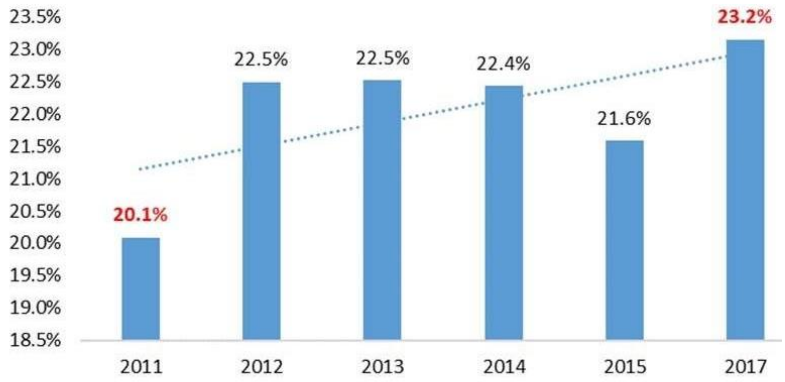
Apparel manufacturing in EU:

- **Developed Western EU countries** remain important players (focusing on high-end apparel production)
- **Developing Eastern EU countries** focus on making products for the mass market

Figure 3 – Value of EU Apparel Output in 2019

Clothing manufacturing in the EU includes two primary categories: one is the medium-priced products for consumption in the mass market, which are produced primarily by developing countries in Eastern and Southern Europe, such as Poland, Hungary, and Romania, where cheap labor is relatively abundant. The other category is the high-end luxury clothing produced by developed Western EU countries, such as Italy, UK, France, and Germany.

Regarding textile production, Southern and Western EU, where most developed EU members are located, such as Germany, France, and Italy, accounted for nearly 75% of EU's textile manufacturing in 2019. Further, of EU countries' total textile output, the share of non-woven and other technical textile products increased from 19.2% in 2011 to 23.0% in 2017, reflecting the ongoing structural change of the sector.

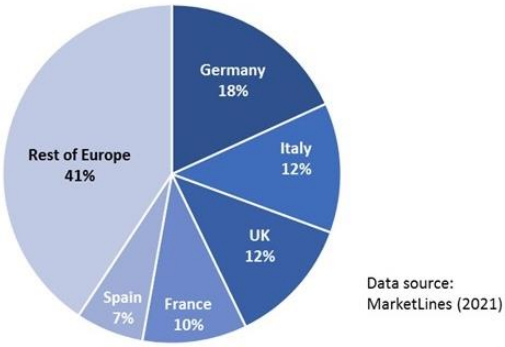


Data source: Eurostat (2020); Note: the 2016 data was not available

Figure 4 – EU Textile Manufacturing: % of Industrial, Technical and Non-Woven Textiles

Regarding textile production, Southern and Western EU, where most developed EU members are located, such as Germany, France, and Italy, accounted for nearly 75% of EU's textile manufacturing in 2019. Further, of EU countries' total textile output, the share of non-woven and other technical textile products increased from 19.2% in 2011 to 23.0% in 2017, reflecting the ongoing structural change of the sector.

It is also interesting to note that in Western EU countries, labor only accounted for 21.7% of the total clothing production cost in 2017, which was substantially lower than 30.1% back in 2006. This change suggests that clothing manufacturing is becoming capital and technology-intensive in some developed Western EU countries — as companies are actively adopting automation technology in garment production.



The top 5 apparel retail markets: **Germany, Italy, UK, France, and Spain** accounted for nearly **60%** of total apparel retail sales in EU in 2020. The market structure remains stable.

Figure 5 – Top EU Apparel Retail Markets, % value in 2020

Because of their relatively high GDP per capita and size of the population, Germany, Italy, UK, France, and Spain accounted for nearly 60% of total clothing retail sales in the EU in 2020. Such a market structure has stayed stable over the past decade[4].

	2000	2010	2015	2017	2018	2019
Textile	68.3%	58.0%	55.2%	54.9%	54.6%	**54.6%**
Apparel	43.6%	32.0%	32.0%	33.4%	33.4%	**37.4%**

Note:
1. Data based on 28 members of the European Union
2. Intra-region trade%= Imports from other EU members/EU total Imports

Figure 6 – Intra-region Trade % in EU Textile and Apparel Industry. Data source: UNcomtrade (2021)

[4] SHENG, Lu, 2021, EU Textile and Apparel Industry and Trade Patterns, available at: https://shenglufashion.com/2021/04/28/eu-textile-and-apparel-industry-and-trade-patterns- updated-april-2021/

Intra-region trade is an essential feature of the EU's textile and clothing industry. Despite the increasing pressure from cost-competitive Asian suppliers, statistics from UNComtrade show that of the EU region's total US$73.8bn textile imports in 2019, as much as 54.6% were in the category of intra-region trade. Similarly, of EU countries' total US$204.0bn clothing imports in 2019, as much as 37.4% also came from other EU members. In comparison, close to 98% of clothing consumed in the United States are imported in 2019, of which more than 75% came from Asia (Eurostat, 2021; UNComtrade, 2021).

EU Extra-region Textile and Apparel Trade

EU's Top Textile Export Market

Export market	2019	2020
United States	13.7%	12.7%
Morocco	8.1%	7.7%
Switzerland	7.1%	8.8%
China	6.9%	7.4%
Turkey	6.4%	6.5%
Top 5 Total	**42.3%**	**43.1%**

EU's Top Apparel Export Market

Export market	2019	2020
Switzerland	21.7%	25.0%
United States	12.8%	10.8%
Russian Federation	8.3%	8.4%
Hong Kong, China	7.4%	6.7%
China	6.3%	8.0%
Top 5 Total	**56.5%**	**59.0%**

EU's Top Textile Suppliers

Source of imports	2019	2020
China	37.3%	64.4%
Turkey	16.4%	9.5%
India	9.1%	4.2%
Pakistan	9.0%	4.8%
United States	4.0%	1.9%
Top 5 Total	**75.8%**	**84.8%**

EU's Top Apparel Suppliers

Source of imports	2019	2020
China	31.2%	33.0%
Bangladesh	18.9%	17.5%
Turkey	11.0%	11.6%
India	5.8%	4.7%
Cambodia	4.3%	3.5%
Top 5 Total	**71.2%**	**70.2%**

Data source: UNComtrade (2021)

Figure 7 – EU Extra-region Textile and Apparel Trade

Regarding EU countries' textile and clothing trade with non-EU members (i.e., extra-region trade), the United States remained one of the EU's top export markets and a vital textile supplier (mainly for technical and industrial textiles). Meanwhile, Asian countries served as the dominant clothing-sourcing base outside the EU region for EU fashion brands and retailers[5].

[5] SHENG, Lu, 2021, EU Textile and Apparel Industry and Trade Patterns, available at: https://shenglufashion.com/2021/04/28/eu-textile-and-apparel-industry-and-trade-patterns- updated-april-2021/

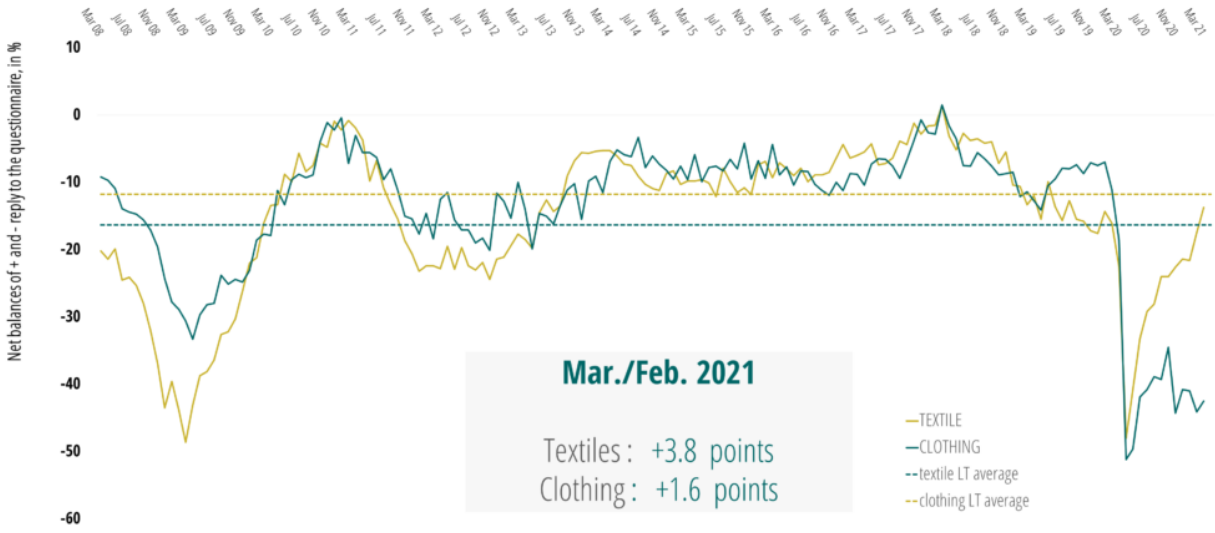


Figure 8 – EU TC Business Confidence Indicator (Mar 2008 – Mar 2021)

The EU textile and clothing industry are not immune to COVID-19. According to the European Clothing and Textile Federation (Euratex), the EU textile and clothing production fell 9.3% and 17.7% respectively in 2020 from a year ago.

According to Euratex, the EU Business Confidence indicator of March 2021 gained momentum, with a confirmed upward trend in the textile industry (+3.8 points), and a modest recovery in the clothing industry (+1.6 points). However, Euratex also noted that EU textile and clothing companies still face daunting challenges and uncertainties in 2021, ranging from the rising raw material price, increasing transportation cost to political instability in some vital sourcing destinations (such as China and Myanmar).

Technical Textiles

In the EU27, the technical textiles industry represents around 30% of the total turnover in textiles, and it accounts for a growing share (27%) of total textile production (see Figure 9).

Technical textiles have been defined as "textiles, fibres, materials and support materials meeting technical rather than aesthetic criteria." They are an input to other industries such as the automotive, medical devices, protective clothing, agro-food sectors, among others. The technical textiles industry is commonly regarded as a top value-added growth industry, where Europe has a strong market position and prominent knowhow potential. However, it is immensely fragmented, comprising a large number of the European SMEs that are specialised in a specific product/market niche (e.g., ballistic protection) or technology (e.g., non-crimp fabric manufacturing).

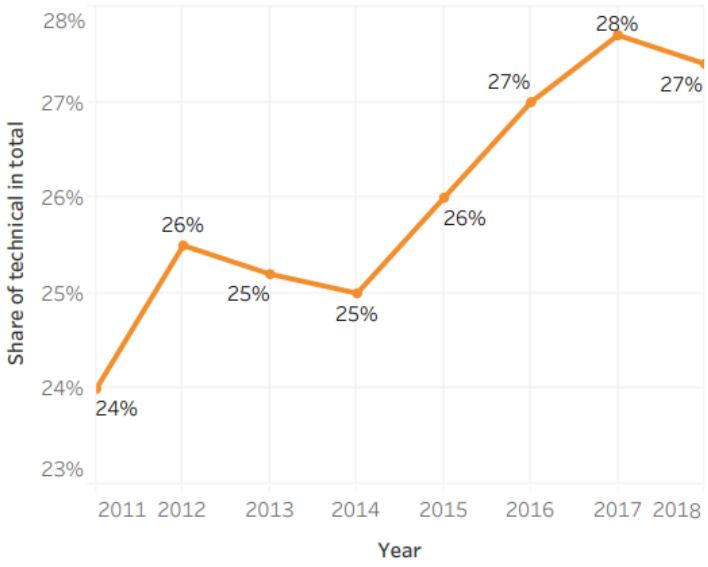


Figure 9 – Share of technical textiles in total production
Source: "Technological trends in the textile industry", European Comission, 2020

The technical textiles industry continues to grow in the EU27, where Germany is the European market leader. In 2018, the European countries with the highest volumes of technical textiles production were Germany (32 000 tonnes), Italy (18 000 tonnes), and the UK (15 000 tonnes), with a total production share of 47%, followed by the Netherlands, Spain, Belgium, France, the Czech Republic, Sweden, Poland, Hungary, and Romania, which together accounted for 43%[6].

On a global level, the US is considered the largest import market for technical textiles with a share of 13.9%, followed by Germany with 7.4%, China with 5%, and Japan with 4.5%. China is the biggest exporter of technical textiles with a global share of 25.5%, followed by Germany (8.4%), the US (8%), and Italy (almost 4%).

The global technical textiles market is predicted to reach €195.9 bn by 2022, an estimated 5.89% growth from 2017.

Growth of automobile, construction, healthcare, packaging, and other sectors provides new opportunities for further development of the technical textiles sector. Technical textiles are used in crop protection, automotive applications, safety components, healthcare, protective clothing, and more (this market is expanding into packaging, sports, and protective wear).

Textiles are widely used in the automotive sector for various applications such as airbags, seat belts, carpets, seat upholstery, and tyres. Non-woven textiles are utilized

[6] EASME, 2020, Advanced Technologies for Industry, available at: https://ati.ec.europa.eu/sites/default/files/2021-

in the indoor lining, floor mats, headliners, belts, etc. Medical textiles are another dynamically expanding field in the technical textile market.

1.1.3. COVID-19 IMPACT

Covid-19 and the lockdown measures have disrupted the European textile and clothing industry as they broke up supply chains, especially China, and profoundly changed consumer behaviour.

In Europe, production fell by 16.8% in the period between January-April 2020 in comparison with 2019. Retail sales of textile products dropped down to 31%. Additionally, employment in the textile sector fell by over 2%.

The whole industry has been hit hard by the Covid crisis. During the second quarter of 2020, the sales of woven fabrics decreased by 35%, knitted fabrics by 44%, and the decline in the clothing industry was twice as bad compared to the worst quarter of the economic and financial crisis in 2009 (-37%). Nevertheless, the pandemic also created an urgent new demand for technical textiles in personal protective equipment (PPE).

Producers in China and Italy were particularly affected by the virus, causing significant disruption on the supply side. McKinsey estimated that revenues for the global textile industry (clothing and footwear sectors) would contract by 27-30% in 2020, year-on-year, although it is predicted that the industry might recover up to 4% in 2021[7].

The issue is severe as the sector comprises firms with less than ten people in the EU who have little room for manoeuvre. Cashflow and liquidity problems have become apparent as the lockdown kept people away from shops.

European and national authorities' fiscal stimulus and solvency measures will help save jobs and enable further investment along the supply chain. As part of the Next Generation EU recovery plan and European Green Deal, the Just Transition Mechanism will provide €150 bn to "incentivise European industrial leadership in strategic sectors and key-value chains, including those crucial to the twin green and digital transitions." Nevertheless, the pandemic has also opened a window of opportunity for the sector to rationalize European production, revise supply chains and push for more digitalisation and green models, as presented in the subsequent sections of the report.

[7] EASME, 2020, Advanced Technologies for Industry, available at: https://ati.ec.europa.eu/sites/default/files/2021-01/Technological%20trends%20in%20the%20textiles%20industry.pdf

More in Depth: With China being a critical global supplier of textile inputs, when disruptions started, the trade impacts on manufacturing consequently extended throughout the whole global market, including the EU's. Reflecting a drop in overall supply, production in Europe declined by more than 10% in Q1 compared to the previous year, reaching a difference of 38% in textile and 57% in the clothing subsectors in April 2020. Concerning employment, the labour market for TC experienced a relatively limited setback over the first months of the crisis, with a 1.5% decrease in textile and 4.9% in clothing in the EU in comparison to 2019, partly thanks to the short-term measures taken at the national level to support employment[8].

Moreover, over the year, some fashion enterprises in specific national industries shifted part of their established production to new categories of products, namely sanitary/masks, pointing to first tendencies towards transformation in supply chain manufacturing in this specific industry subsector. Due to lockdowns that forced the shutdown of shops and mobility restrictions in many countries, demand for especially the clothing subsector of the overall industry dropped significantly, with retail sales falling by 18.8% in the EU during Q1. 60% of European textile companies interviewed in a survey carried out between March and April 2020 expected sales to drop by more than half; 7 out of 10 faced severe financial difficulties, and 8 out of 10 stated that they reduced, at least temporarily, their workforce.

While retail sales dropped, sales through online channels hit historical records in some EU countries, pointing to a change in consumer behaviour towards e-commerce, which continued over the rest of 2020. However, such a transition to online shopping failed to offset the overall drops in sales of the whole industry.

The industry started to recover in Q3 2020, although at a relatively slow pace. Production experienced a rebound from Q2 by 25% in the textiles and 33% in the clothing subsectors. Sales figures also improved, with an overall retail sales recovery by 62% from Q2.

Nonetheless, all-year growth figures for the industry are negative when compared with 2019. Production and retail sales dropped by 15% and 9.4% for clothing and 7% and 9.7% for textile, respectively, driven mainly by a decreased interest to buy clothes (lack of events and ungratifying buying experience due to restrictions/shutdowns). The trends in employment worsened by the end of the year, with drops by 2.9% and 7.5% for the

[8] Policy Department, European Parliament, 2021, Impacts of the COVID-19 pandemic on EU industries, available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662903/IPOL_STU(2021)662903_EN.pdf

respective subsectors in Q3 2020.

Recovery outlook: Overall turnover in the industry is expected to bounce back by about 15% in 2021 (with a potential catch-up of consumer spending), but it is not expected to return to pre-crisis levels until Q3 2023, assuming a progressive easing of the sanitary emergency and substantial support measures to the economy. Estimates for total employment in the sector suggest that the actual shock in the labor market of TC is yet to come, as the latter could decline by as much as -8% (about 158,000 jobs) by the end of 2021. Company count, in addition, is expected to decrease by -6% (about 13,000 companies) in the same year. Based on these predictions, the recovery scenario of the overall sector will likely be U-shaped, with increasing uptakes in output figures but possible further pitfalls in employment figures, as well as in the wearing clothing subsector, whose performance appears to be at least partly dependent on trends relative to lockdown and other government restriction measures.

Digitalization and shifts in consumer preferences towards online commerce will play an essential role in the speed of the (sub) sector's recovery. Based on trends relative to digital sales in Europe since the start of the COVID-19 outbreak, the EU showed a lower e-commerce understanding than other advanced economies such as the US or Japan. However, estimates for 2021 foresee sales through digital channels to continue growing in Europe by more than 30% from 2019[9].

1.1.4. INNOVATION: MAJOR TRENDS IN INNOVATION

For several years, the textile industry has been going through an intensive digital transformation process driven by increased consumer demand for personalised products, the connection of textile manufacturing devices based on IoT applications, and more automation of production and logistics processes.

Technological innovations created new business models and opportunities for textile companies.

For instance, digital textile printing has given companies and consumers the ability to customize and produce consumers' designs and ideas quickly and relatively cheaply. Innovation in material use has resulted in attractive new solutions, such as waste from

[9] Policy Department, European Parliament, 2021, Impacts of the COVID-19 pandemic on EU industries, available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662903/IPOL_STU(2021)662903_EN.pdf

citrus peels, milk, pineapples, and coffee grounds to produce new materials for clothing[10].

The European textiles industry is under much pressure to be innovative. Many textile companies outsource R&D, making the innovation process fragmented (ad-hoc rather than continuous initiatives).

The Covid pandemic accelerated the ongoing digitalization trends in the textile industry.

As a consequence of social distancing, communication within and between firms in the textile supply chain happens through digital means (i.e., presenting samples and innovations digitally). Covid prompted urgent changes in communication, leading to more digital exchanges and the use of visualization techniques.

Moreover, as it has been highlighted during a recent international conference: "The textile industry plays a pivotal role in the times of Covid in providing personal protective equipment with functional textile materials and devices, including remote diagnosis and contact tracing or smart textile wearables for combatting coronavirus infections." The related technological innovations will play an essential part in solving the current crisis.

In particular, the field of wearable electronics covers many aspects of cutting-edge R&D and provides an opportunity for textile manufacturers and fashion designers to innovate with a range of advanced technologies, including Advanced Materials, Photonics, and Nanotechnology[11].

Sector	Key challenges
Healthcare and medical	• development of controlled drug release fibre and textile structures for therapeutics of different skin conditions development of garments and home textile products with fully integrated bio- monitoring, active systems to improve life quality and ICT systems enabling remote monitoring of patients and assisted living services for “better ageing concepts” • development of fibre and textile structures with enhanced thermal/breathability electro-active properties with integration of new surface functionalities for improving barrier (antiviral and antibacterial) properties

[10] EASME, 2020, Advanced Technologies for Industry, available at: https://ati.ec.europa.eu/sites/default/files/2021-01/Technological%20trends%20in%20the%20textiles%20industry.pdf

[11] EASME, 2020, Advanced Technologies for Industry, available at: https://ati.ec.europa.eu/sites/default/files/2021-01/Technological%20trends%20in%20the%20textiles%20industry.pdf

Sector	Key challenges
Automotive and aeronautics	• integration of fully integrated and printed electroactive and interactive sensors and actuators that enable the development of ubiquitous sensing and interactive surfaces, while also integrating fully embedded (or printed and/or fibre and yarn integrated) haptic feedback systems via both lighting integration and mechanical stimuli responses • integration of fully customizable self- lighting materials based on active fibres and yarns, and integration or programmable textile matrixes for interactive sensing
Sports	• development of lightweight performance garments having new textile surface coatings enhancing thermal management (insulation), controlled drug release for muscle care, and also proving optimized comfort, low pill, low shrink and fast drying • integration of low power/autonomous bio-monitoring and/or integrated ICT and IoT communication systems for training monitoring and performance • assistance and integration concepts of training analytics, always connected and data sharing for garment/textile structures “peripherals”
Personal protection	• the integration of geo tracking and personal GPS systems (Global Positioning Systems), physiological and biometric monitoring, embedded and integrated communications and energy harvesting, with all data monitoring systems sharing data in real-time • integration of cooling/heating systems into garments
Building and living	• development of new functional textile materials using nano-materials and industrial waste, eco-friendly technologies (like ultrasonic deposition, bi/tri- component fibres, UV curing coatings), considering multilayer approaches focus on high thermal performance (applying eco-efficient heating and cooling systems, together with low thermal conductivity and diffusivity coatings and additives, infrared reflective and phase change materials), in order to achieve Net Zero Energy Buildings (NZEB) textile functionalization with smart and efficient systems like sensorization, communication systems and actuators, considering printing electronics approaches, in order to maximize comfort, well-being develop interoperability between connected devices

1.2. ADVANCED MANUFACTURING MARKET

1.2.1. GLOBAL KEY FACTS AND FIGURES OF BOTH SECTORS (WORLD, EUROPE, SPAIN + FRANCE + PORTUGAL)

Advanced Manufacturing is a strong and powerful key enablibng technology. The manufacturing sector includes a vast range of activities and production techniques, from small-scale enterprises using traditional production techniques, such as the manufacture of musical instruments, to very large enterprises sitting atop a high and broad pyramid of parts and components suppliers collectively manufacturing complex products, such as aircraft. An analysis of the manufacturing sector as a whole gives an idea of the scale of this sector. It should be noted, however, that indicators of its inputs (for example, labor or capital goods), its performance, or its size structure are effectively an average across very different activities. While this can also be said of other large and diverse sectors, such as distributive trades and transport services, the manufacturing sector is probably the most varied activity within the non-financial business economy at the NACE section level of detail[12]. At the NACE division, level the manufacturing is composed by 24 different sub-sectors.

CLAMTEX partner Clusters activities focus on Production technologies and Advanced manufacturing technologies that are used in a wide range of manufacturing sub-sectors. Although the more traditional and core focus of the production technologies clusters' members activities relates to manufacturing of machinery and equipment for industry, metal products and other non-metallic materials. Nowadays the advanced technologies and solutions are getting a huge impulse within the frame of digital transformation and Industry 4.0 uptake as they are being integrated in many industrial processes and products in the vast majority of the Manufacturing sub-sectors' industries.

Considering the transversal dimension of the Manufacturing technologies and Advanced manufacturing technologies throw-out all the industrial/manufacturing sectors and to give a comprehensive overview, including strategic users market evolutions, the analysis and statistics presented hereafter will refer to the manufacturing sector as a whole.

[12] Manufacturing statistics - NACE Rev. 2

Manufacturing sector

Around 1 in 10 (8.8 %) of all enterprises in the EU-27's non-financial business economy[13] were classified to manufacturing in 2017, a total of almost 2.0 million enterprises.

The manufacturing sector employed 28.5 million persons in 2017 and generated a turnover of EUR 7 230 000 million and EUR 1 820 billion of value added. By these measures, manufacturing was the second largest of the NACE[14] sections within the EU-27's non-financial business economy in terms of its contribution to employment (22.8 %) and the largest contributor to non-financial business economy value added, accounting for more than one quarter of the total (29.3 %).[15]

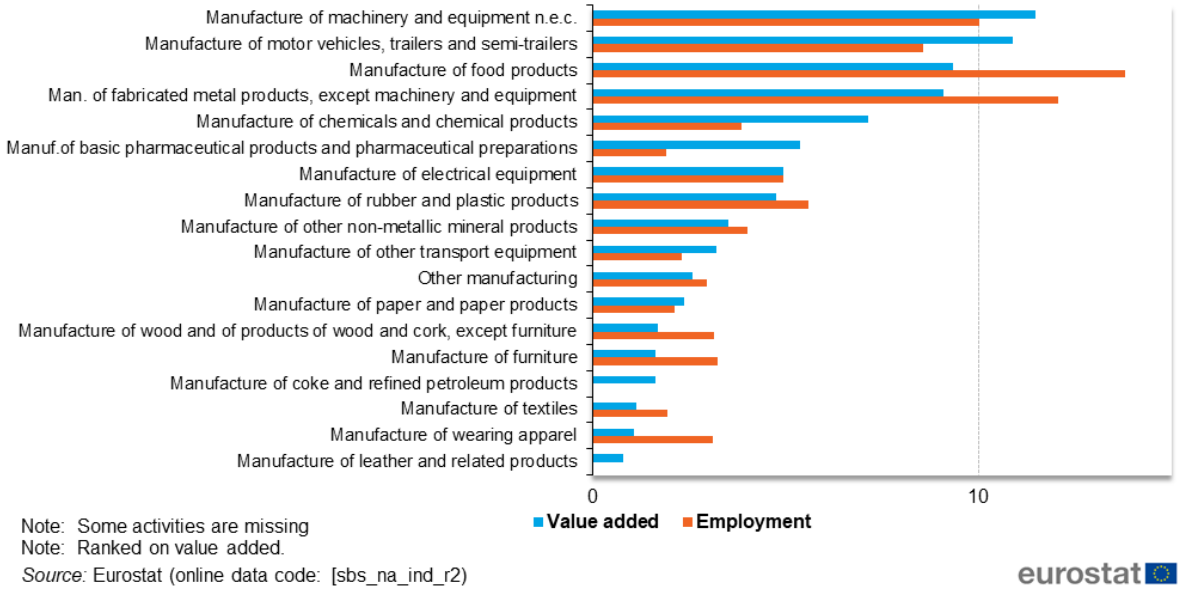


Figure 10 – Sectorial Analysis of Manufacturing – EC-27, 2017 (Nace Section C), % share of sectoral total. Source: EUROSTAT 1

EU exports consist mainly of manufactured products: both in 2010 and 2020 their share was more than 80 % of total EU exports. Manufacturing provides jobs and wealth in every Member State and region of the EU, and economic activity is highly interlinked[16]. Because of the tradable nature of manufactured goods, the relative importance of manufacturing within the non-financial business economy varies between EU Member States, with sometimes very pronounced specialisations at the subsector level[17].

[13] The non-financial business economy includes the sectors of industry, construction, distributive trades and services. This refers to economic activities covered by Sections B to J and L to N and Division 95 of NACE Rev. 2 and the enterprises or its legal units that carry out those activities.
[14] Statistical classification of economic activities in the European Community
[15] Manufacturing statistics - NACE Rev. 2

[16] Factories of The Future - Multi-Annual Roadmap
[17] Manufacturing statistics – NACE Rev. 2

When looking at manufacturing's importance in the Member States' economies, Figure 11 shows that the share of value added[18] of manufacturing within the non-financial business economy's varied in 2017 from 12.3 % in Cyprus to more than 37.0 % of the total in Slovenia, Slovakia, Hungary and Czechia, with Ireland having the highest share (47.0 %). The range in employment terms was similar, from 11.3 % in the Netherlands to 35.4 % in Czechia[19].

For Spain and France the share of added value within the non-financial business economy was slightly below to 25%, and closer to 26% for Portugal (below the EU-27 average of approximately 29%).

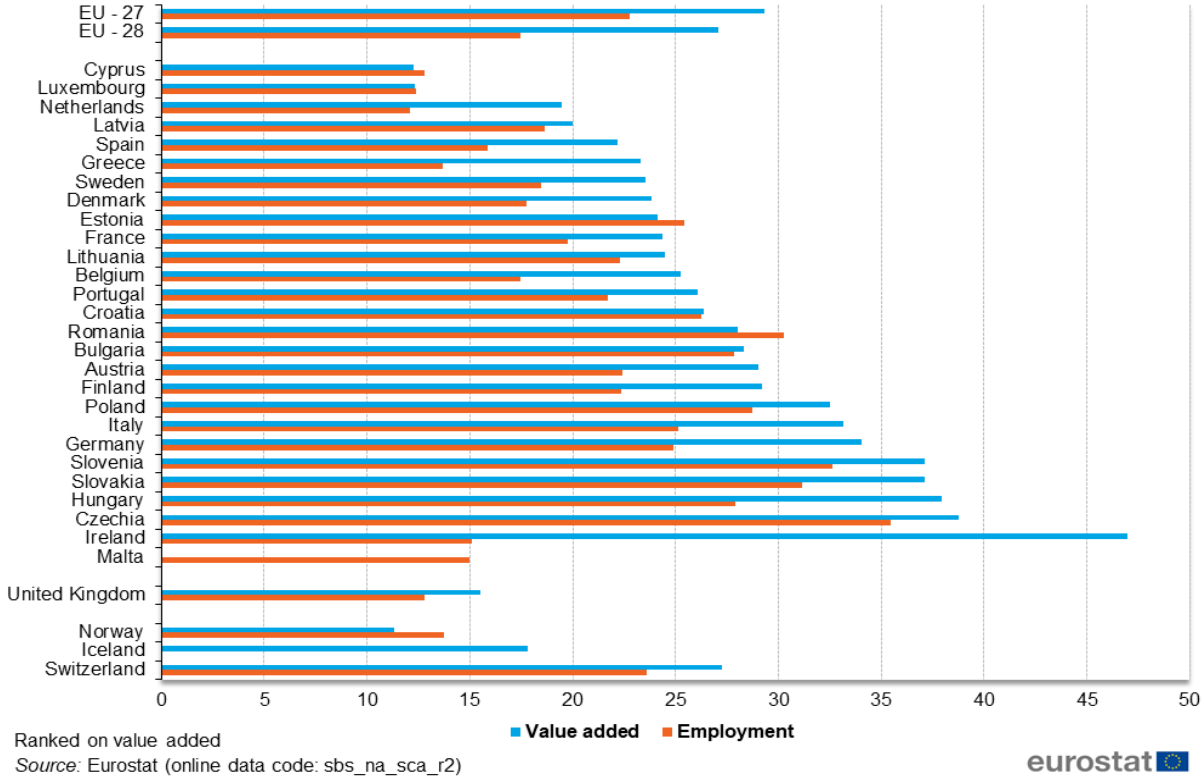


Figure 11 – Relative Importance of Manufacturing, EU-27, 2017 (Nace Section C), % share of value added and employment in the non-financial business economy total)

Source: EUROSTAT 2

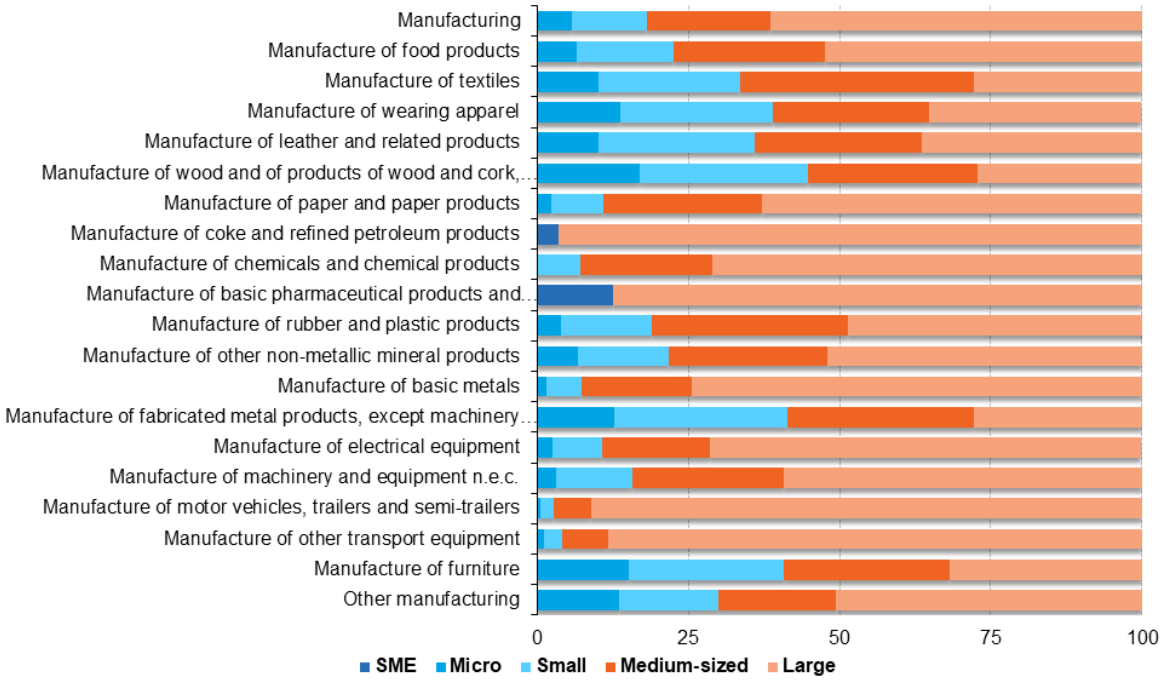
Industrial production is a key driver for innovation, economic growth and job creation in Europe and the manufacturing industry is a strong asset, accounting for 2 million enterprises and 33 million jobs.

SMEs are the backbone of manufacturing industry in Europe. Micro, small and medium enterprises provide around 40% of the value added by manufacturing while they provide

[18] Gross value added (GVA) is defined as outputs (at basic prices) minus intermediate consumption (at purchaser prices); it is the balancing item of the national accounts' production account

[19] Eurostat

around 55 % of manufacturing employment in 2017[20]. However, as shown in the figure below, despite the highest contribution of medium-sized enterprises in certain of the manufacturing sub-sector, the contribution of large enterprises remains important in term of added value.



Note: Activities which are not shown are incomplete. For the purpose of the article some percentages have been calculated for confidential data, which causes a lower reliability.

Source: Eurostat (online data code: sbs_sc_ind_r2)

eurostat

Figure 12 – Sectorial analysis of value added by enterprise, size, class (Nace Section C), % share of sectoral value added. Source: EUROSTAT 3

Among the EU Member States, Germany stood out as its manufacturing sector contributed almost one third (32.5 %) of the EU-27's value added in 2017, followed by Italy who contributed with 13.3 %[21]. France, Portugal and Spain contributed respectively with 13.2%, 1.2% and 6.1%.

In total, Manufacturing enterprises generated in 2017 approximately EUR 240.3 million of value added in France, EUR 21.8 million in Portugal and EUR 110.8 million in Spain, while providing respectively employment to 3 103.6 thousand persons, 711.7 thousand persons and 1 917.7 thousand persons the same year (Figure 13).

[20] EFFRA FACTORIES OF THE FUTURE https://www.effra.eu/sites/default/files/factories_of_the_future_2020_roadmap.pdf

[21] Eurostat

INDIC_SB	Enterprises - number	Turnover or gr...	Value added a...	Personnel costs ...	Net investment in tangible goods...	Employees - number
TIME	2017	2017	2017	2017	2017	2017
GEO						
European Union - 27 ...	1 964 946	7 230 000.0 (de)	1 820 000.0 (de)	1 110 000.0 (de)	:	26 900 000.0 (de)
European Union - 28 ...	2 101 666	7 930 000.0 (de)	2 020 000.0 (de)	1 220 000.0 (de)	:	29 400 000.0 (de)
Belgium	36 801	267 652.4	56 092.4	30 037.7	9 096.0	463 688
Bulgaria	31 272	33 370.8	7 767.2	3 699.1	1 981.8	533 151
Czechia	175 894	178 105.9	39 930.5	21 638.1	8 033.6	1 160 145
Denmark	15 343	115 938.8	35 623.4	20 110.0	3 425.0	304 687
Germany (until 1990 ...	190 541	2 193 357.5	592 027.2	413 971.2	63 021.3	7 261 022
Estonia	7 507	12 474.7	3 018.2	1 978.4	545.6	107 942
Ireland	16 701	226 192.9	97 262.2	11 424.7	-1 508.9	212 027
Greece	57 373 (p)	54 119.8 (p)	11 521.2 (p)	6 034.0 (p)	1 328.8 (p)	261 362 (p)
Spain	168 717	505 350.9	110 841.4	67 211.7	16 036.9	1 811 226
France	197 657 (b)	1 021 247.9 (b)	240 268.1 (b)	175 396.6 (b)	12 647.6 (b)	3 020 803 (be)
Croatia	19 539	21 497.5	6 126.4	3 535.1	933.8	259 020
Italy	383 585 (b)	965 031.0 (b)	241 413.9 (b)	143 779.5 (b)	14 072.7 (b)	3 263 712 (b)
Cyprus	5 024	3 411.4	1 077.6	628.0	138.1	30 141
Latvia	10 921	8 409.0	2 333.9	1 297.2	448.2	114 801
Lithuania	20 268	20 257.7	4 552.7	2 582.4	911.6	207 811
Luxembourg	771	13 703.0	3 125.2 (b)	1 995.9	373.5	33 944
Hungary	50 809	109 581.7	24 176.0	11 358.7	6 424.5	730 824
Malta	2 146	: (c)	: (c)	: (c)	: (c)	: (c)
Netherlands	66 662	345 979.9	70 850.4	38 651.6	8 441.9	654 940
Austria	25 477	191 203.9	56 265.9	35 641.8	7 001.6	618 736
Poland	198 757	321 925.9	70 361.0	34 119.7	13 742.6	2 438 203
Portugal	67 555	90 310.8	21 842.4	12 402.2	4 487.1	678 765
Romania	49 837	83 852.6	18 742.1	11 707.5	6 820.8	1 207 044
Slovenia	19 376	29 353.0	8 365.7	4 940.2	1 574.2	193 096
Slovakia	72 563	76 382.2	14 075.1	7 900.2	3 945.4	441 378
Finland	20 176 (b)	123 675.7 (b)	29 753.2 (b)	16 890.3 (b)	4 261.6 (b)	321 732 (b)
Sweden	53 674	213 355.3	55 108.7	35 480.7	7 702.6	545 865
Iceland	2 106 (p)	6 566.6 (p)	1 981.6 (p)	1 552.4 (p)	:	22 336 (p)
Norway	17 001	85 695.0	21 429.9	14 658.6	2 442.2	217 542
Switzerland	20 050	298 061.2	98 363.7	57 276.1	8 553.5	:
United Kingdom	136 720	700 030.8	194 012.5	102 841.0	22 263.2	2 526 036

Figure 13 – Key Manufacturing Indicators, (Nace Section C) EU27, 2017. Source: EUROSTAT

At world scale, only few countries hold significant shares in world manufacturing value added (MVA)[22] and world exports. The country with the biggest impact is China, which in 2018 had a share of 17.2% in world manufacturing exports and a share of 28.9% in world MVA. Other examples of countries with major shares are the United States, Germany, Japan, the Republic of Korea and India.[23]

Germany (4th) and Italy (7th), together with France (8th) and United Kingdom (9th), are the four European countries listed among the world top 10 countries when looking at the share of world manufacturing value added index (2018)[24]. European countries have high capacities to produce and export manufactured goods. Eastern Asian countries stand out in terms of their world impact and their technological deepening and upgrading.

[22] "Manufacturing value added (MVA) of an economy is the total estimate of net-output of all resident manufacturing activity units obtained by adding up outputs and subtracting intermediate consumption. Measurement of MVA requires appropriate demarcation of the type of economic activity and of the territory in which the activity takes place. The boundary of manufacturing as an economic activity is defined by the International Standard Industrial Classification of All Economic Activities (ISIC)."

[23] United Nations Industrial Development Organization, 2020. Competitive Industrial Performance Report 2020. Vienna, Austria

[24] United Nations Industrial Development Organization, 2020. Competitive Industrial Performance Report 2020. Vienna, Austria – countries profiles: share of World manufacturing Value Added Index.

Jointly, these two regions occupy eight of the top-10 positions in the Competitive Industrial Performance (CIP)[25] global ranking.

If we look at countries level, France positions at the 13th, Spain at the 18th and Portugal at the 33th. This reflects their good production capacity, technological deepening and upgrading and impact on the global market of manufactured goods.

France

Performance indexes

	Rank 2018	Score 2018	World Average	Rank 2017
Competitive Industrial Performance Index	13	0.237	0.067	13 →
Manufacturing Value Added Indexes				
Manufacturing Value Added per Capita Index	26	0.157	0.076	26
Share of Manufacturing Value Added in GDP Index	92	0.286	0.343	92
Share of Medium and High-Tech Activities in Total Manufacturing Value Added Index	15	0.614	0.302	13
Industrialization Intensity Index	33	0.450	0.323	32
Share of World Manufacturing Value Added Index	8	0.069	0.023	9
Manufacturing Export Indexes				
Manufacturing Export per Capita Index	22	0.212	0.103	22
Share of Manufacturing Exports in Total Exports Index	31	0.912	0.631	30
Share of Medium and High-Tech Activities in Total Manufacturing Export Index	18	0.730	0.397	16
Index Industrial Export Quality Index	16	0.821	0.514	15
Share in World Manufacturing Export Index	6	0.210	0.039	6

Spain

Performance indexes

	Rank 2018	Score 2018	World Average	Rank 2017
Competitive Industrial Performance Index	18	0.181	0.067	19 ↑
Manufacturing Value Added Indexes				
Manufacturing Value Added per Capita Index	31	0.136	0.076	31
Share of Manufacturing Value Added in GDP Index	60	0.351	0.343	61
Share of Medium and High-Tech Activities in Total Manufacturing Value Added Index	34	0.494	0.302	34
Industrialization Intensity Index	39	0.423	0.323	38
Share of World Manufacturing Value Added Index	16	0.043	0.023	16
Manufacturing Export Indexes				
Manufacturing Export per Capita Index	32	0.164	0.103	28
Share of Manufacturing Exports in Total Exports Index	45	0.880	0.631	58
Share of Medium and High-Tech Activities in Total Manufacturing Export Index	39	0.613	0.397	34
Index Industrial Export Quality Index	33	0.747	0.514	33
Share in World Manufacturing Export Index	13	0.117	0.039	13

Portugal

Performance indexes

	Rank 2018	Score 2018	World Average	Rank 2017
Competitive Industrial Performance Index	33	0.097	0.067	34 ↑
Manufacturing Value Added Indexes				
Manufacturing Value Added per Capita Index	39	0.098	0.076	37
Share of Manufacturing Value Added in GDP Index	59	0.364	0.343	58
Share of Medium and High-Tech Activities in Total Manufacturing Value Added Index	65	0.316	0.302	65
Industrialization Intensity Index	64	0.340	0.323	62
Share of World Manufacturing Value Added Index	50	0.007	0.023	50
Manufacturing Export Indexes				
Manufacturing Export per Capita Index	27	0.182	0.103	29
Share of Manufacturing Exports in Total Exports Index	17	0.948	0.631	15
Share of Medium and High-Tech Activities in Total Manufacturing Export Index	61	0.477	0.397	62
Index Industrial Export Quality Index	40	0.713	0.514	42
Share in World Manufacturing Export Index	35	0.029	0.039	38

1st DIMENSION: CAPACITY TO PRODUCE AND EXPORT MANUFACTURES
2nd DIMENSION: TECHNOLOGICAL DEEPENING AND UPGRADING
3rd DIMENSION: WORLD IMPACT

Figure 14 – Performance Index – Portugal, France and Spain
Source: United Nations Industrial Development Organization, 2020 – countries profiles

[25] Ibid. The CIP index indicates how successful a country's industries are at producing and selling their goods in domestic and foreign markets while moving along the technological ladder. Consequently, the CIP index enables cross-country comparisons of industrial competitiveness while providing strong policy signals, pointing towards developmental obstacles in countries' industrial development.

The three countries have strong industrial regions with high employment within manufacturing sector (Figure 14). Among them, we can identify the Norte region in Portugal, Catalunya and Valencia in Spain, and Pays de la Loire in France.

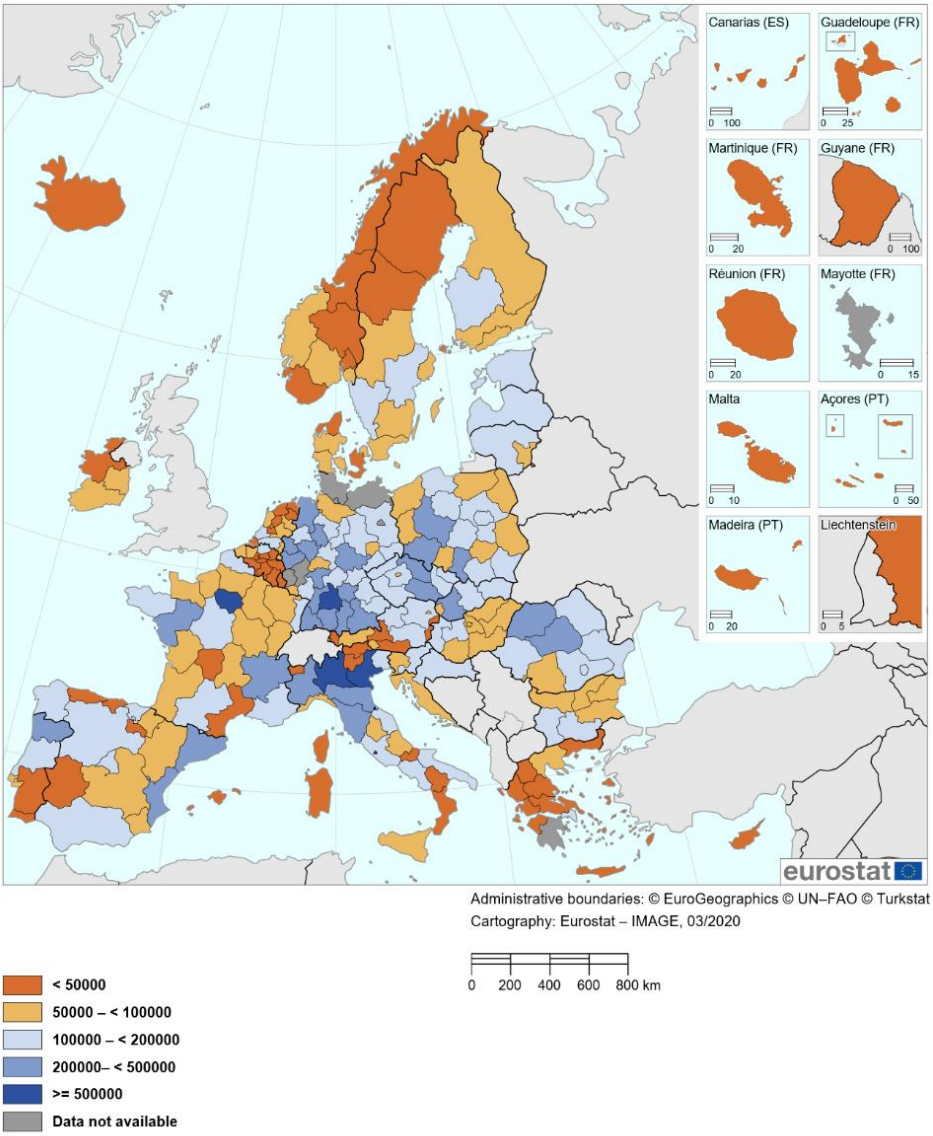


Figure 15 – NUTs 2 regions in terms of employment, 2017 (Nace Section C)
Source: EUROSTAT

They also have different industrial structures and specialization as illustrated in the table below. “Food and beverages”, “Machinery and equipment” and “Motor vehicles, trailer and semi-trailers” manufacturing sub-sectors are identified in the three countries but present different level of importance.

Top 5 - Manufacturing Composition (2018)	France	Portugal	Spain
Food and beverages	19.3%	15.1%	18.7%
Machinery and equipment n.e.c.	11.1%	7.1%	9.1%
Motor vehicles, trailers, semi-trailers	8.3%	6.2%	10.2%
Fabricated metal products		10.8%	10.1%
Chemicals and chemical products	13.0%		12.3%
Non-metallic mineral products		6.2%	
Other transport equipment	8.9%		

Figure 16 – Top 5 Manufacturing Composition (2018)
Source: own production based on UNIDO – Countries profiles 2020

1.2.2. MARKETS: EVOLUTION, PAST, PRESENT AND FORECASTS

Manufacturing refers to industrial production process to transform raw materials into new products for use or sale. Substantial alteration, renovation or reconstruction of goods is generally considered manufacturing, as well as assembly of the component parts (whether self-produced or purchased) of manufactured products[26].

Manufacturing is considered an integrated concept covering different levels from machines to production systems to an entire business level operation. Manufacturing is an indispensable element of the innovation chain: it enables technological innovations to be applied in goods and services; it is an RD & I-intensive activity[27].

Since the first industrial revolution, manufacturing continuously evolved. It is now undergoing a new revolution; the fourth Industrial revolution build on the digital revolution that has been occurring since the middle of the last century.

This revolution is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres, driving a need for structural changes and transformation of systems of production, management, and governance[28]. This revolution echoes the world economy and social transformation that we experience in the way we live, work and behave since some years now. These changes generate important megatrends and drivers for the manufacturing.

[26] Eurostat
[27] Factories of The Future – Multi-Annual Roadmap
[28] World Economic Forum, 2016, Klaus Schwab

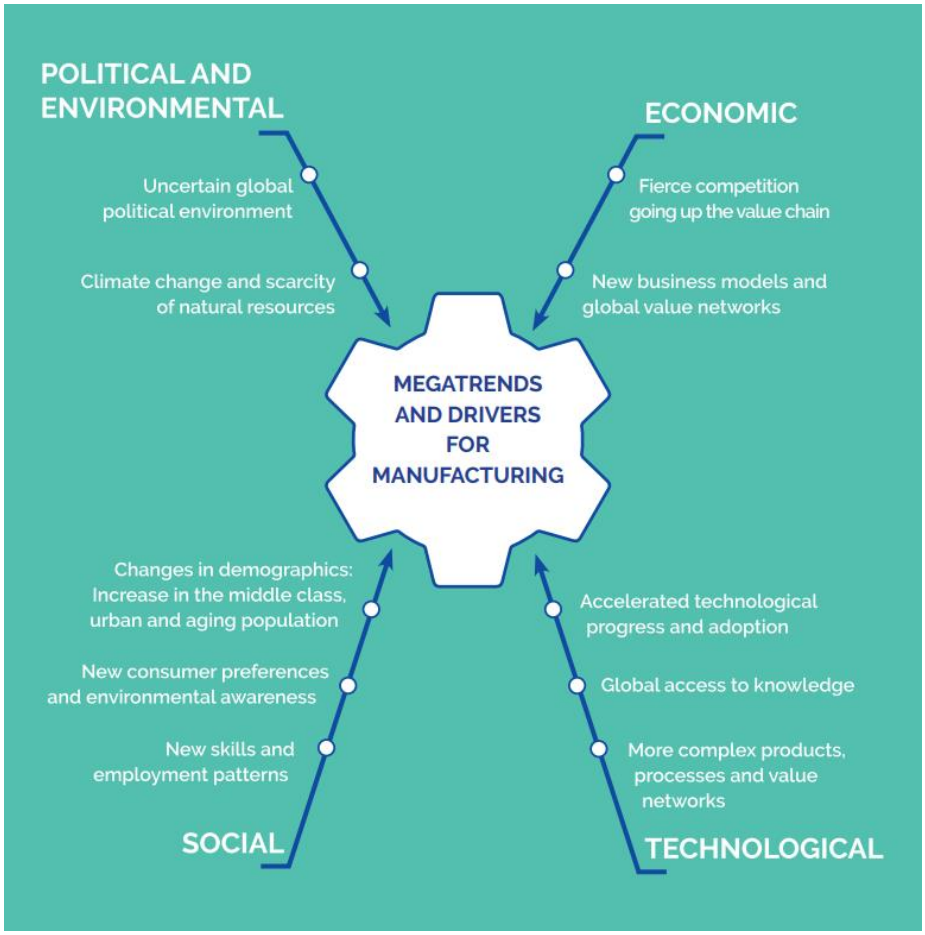


Figure 17 – Megatrends and Drivers for Manufacturing

Source: ManuFUTURE - VISION 2030

To respond to the megatrends and drivers identified, European Manufacturing must evolve to become even more flexible. They must also be more adaptable and reach beyond the customer expectations in terms of product performance, quality and service[29].

This implies significant changes: from technologies to business models, from research to training, from individual customization to social behavior.

Due to their “enabling” role, the advanced manufacturing systems support directly this revolution or more generally support the modernization and transformation of EU industries.

Advanced manufacturing technologies like 3D printing, the internet of things (IoT), advanced robotics, artificial intelligence, big data and additive manufacturing are the tools for the “Industry 4.0”. They enable, among other, improvements of systems

[29] Report from Manufuture, high-level group, 2018: ManuFUTURE – VISION 2030

connectivity and data management, analytics and intelligence, automation, Human-machine interaction and advanced engineering [30], supporting development of new products and enabling a cost-effective, resource-efficient and timely production.

As stated by the European Factory of the Future Research Association (EFFRA) in the future European public private partnership for manufacturing "Made in Europe", European manufacturing is at the center of a twin ecological and digital transition, being both driver and subject to these changes.

European industry is also facing increasing competition and manufacturing companies must maintain technological leadership and stay competitive. The size and the complexity of the associated challenges -such as the integration of Artificial Intelligence, the use of industrial data, the transformation into a circular economy and the need for agility and responsiveness requires companies' support and trans-national cooperation[31].

1.2.3. COVID-19 IMPACT

Although a global pandemic has been an imminent risk for several years with controlled cases in the last decades like ebola or Influenza, COVID-19 came as a shock for the global society. Not only for the health systems but also for the economy and society worldwide.

The world as we know is now living extraordinary challenges and uncertainty, and the successful measures used in the past during other global tragedies will not solve the problem, meaning that new measures will need to be implemented to launch again the economy and to manage the immediate impact of the pandemic and its consequences in the global society.

The most industrialised countries are taking similar actions towards the recovery of the economy, developing strategic economic packages that will shape the state of the economy for years to come. This might be the right time, not only to react to the pandemic, but also to use this moment to build a more prosperous, equitable and sustainable world, taking advantage of all the lessons learned within this painful moment.

To respond to the COVID-19 pandemic European countries, as the countries from the rest of the world, applied various measures that severely affected the European Union (EU) industries.

[30] Mckisley, 2020, Industry 4.0: Reimagining manufacturing operations after COVID-19
[31] EFFRA, the future European public private partnership for manufacturing "Made in Europe"

These measures affected directly the industrial production during 2020. After severe decreases in April (-18.6 %) and March (-10.1 %) industrial production had strongly recovered in May (12.0 %), June (9.5 %), and July (4.6 %). In late summer, the production level had remained relatively stable and in October and November 2020 production had increased respectively by 2.1 % and 2.0 % [1].

In February 2021, industrial production in the EU decreased by 0.9 % compared with the January 2020. This decrease followed a moderate increase of 0.8 % in January and a stagnation of production in December 2020.

Figure 18 shows the 2020 development in industrial production for total industry and the various main industrial groupings, i.e. intermediate goods, capital goods, energy, durable and non-durable consumer goods. [2]

The core of production technologies and advanced manufacturing technologies, mainly included in capital goods and intermediate goods [3], were severely impacted by the industrial production decrease.

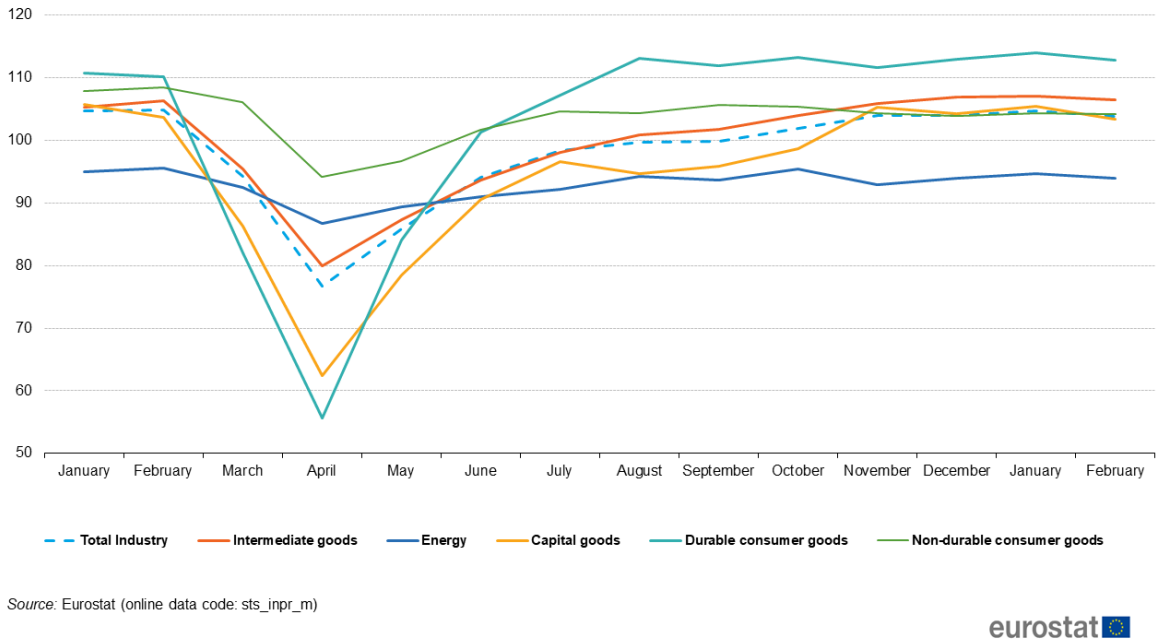


Figure 18 – EU development of Industrial Production, January 2020 to February 2021
Source: EUROSTAT

The total loss of industrial production due to the Covid-19 crisis has not yet been recovered, but to some extent, the dynamics that can be seen in the period September-December 2020 point to an adaptation of the EU manufacturing companies to the new

realities of the pandemic and a milder impact of the second lockdown upon the EU27 industry [4].

Concrete examples, from rapid redeployment of underutilized factories, factories that have remained open and shifted their productions to help fight COVID-19, to the learning of new ways to secure and build local, regional, national and global supply chains, have shown the importance for manufacturing to strengthen its resilience and adaptability [5].

A high level of innovation, a mix of multidisciplinary competences and creativity helped to address the disruptions created by the pandemic. One measure that could be observed across industries and regions in Europe was that technology helped manufacturers respond more quickly by enabling agility in the scaling up and shifting of production to manufacture new products (masks, ventilators, hand sanitizers and PPE...)[6].

The coronavirus pandemic highlighted the necessity of Industry 4.0 technologies for manufacturers engaged in a global marketplace that will require more agile and flexible production systems and supply chains.

The remote interaction and asset management during the pandemic has also emphasised the necessity of advanced manufacturing technologies. They can support in several ways: automation can help operation with fewer people on the shop floor, IoT and machine-monitoring solutions can be used by remote workforce to keep track of production, apps can be used to facilitate communication and collaboration between in-person shop-floor personnel and their remote supervisors. Technology is also helping manufacturers train employees on new production processes on the job for faster new product introduction.

The COVID-19 crisis shown that factories that had invested in advanced manufacturing technologies were more resilient to the crisis. It is likely to lead to an acceleration of the adoption of advanced manufacturing technologies in the future.

1.2.4. INNOVATION: MAJOR TRENDS IN INNOVATION

To support the transition toward factory of the futures, four main objectives have been defined by the EFFA. These objectives are in line with the EU's political priorities addressing manufacturing industries:

Sector	Key challenges
International Industrial Performance	• control cost, quality and timing in production, allowing European industries to stay competitive through innovation • reach speed, precision, quality and reliability with flexibility and agility, this means manufacturing companies need to produce from very small lot-sizes to big volumes and there is a growing need for the ability to quickly scale up from small to big lot-sizes whilst retaining the required quality in zero-defect and first-time-right production • respond quickly to market disruptions, changing customer demands, fluctuating characteristics of raw materials and components, and advanced emerging technologies that can be potential differentiators • increase quality and efficiency and reduce Total Cost of Ownership •
Sustainable Manufacturing	• take into account environmental and societal constraint in the manufacturing process • reduce environmental footprint, in particular through optimizing processes and equipment energy efficiency, reinforcing and developing the recycling and waste treatment sector and develop circular economy approaches • exploit the possibilities offered by advanced materials, digital technologies and manufacturing technologies to achieve a considerable reduction of the ecological impact and CO2-emissions • increase recycling and re-use of materials and components
Digital Manufacturing	• turn the production more agile, interconnected, smart, vertically integrated (with every internal services) as well as horizontally integrated (connecting the value chain actors, such as suppliers, clients,) • increase traceability and speed up the time to market while adapting to demands fluctuation • improve digital platforms, build new reliable architecture to foster exchange and improve real time data management on the overall value chain • assure cybersecurity and data protection • build new business models based on data exploitation

Sector	Key challenges
The Human Factory	• earn early stage operators' acceptability for new technologies and accelerate their adoption in the factory • improve competitiveness through operators' innovation capacity, creativity and performance • design new work practices by incorporating new tools based on advanced technologies and involving employees in the co-design • implement good change management strategies, in order to avoid decision-makers and/or work force reluctance to the unknown • facilitate access to knowledge and accelerate gain in experience • exploit new technology to increase physical, sensory, communication and cognitive capacity • foster implication, innovation and motivation

2. SUSTAINABILITY AND CIRCULAR ECONOMY

2.1. CHALLENGES FROM THE TEXTILE SECTOR

Fast Fashion

The textiles market is highly globalized, and millions of producers and billions of consumers across the world are involved in so-called linear value chains. These chains - from raw material extraction to production, transport, consumption and waste — include little or no reuse or recycling. Since 1975, the global production of textile fibers has almost tripled. Today, 60 % of textile fibers are synthetic.

Polyester is the most commonly used fibre, produced from carbon-intensive processes requiring more than 70 million barrels of oil each year. The remaining fibers are mainly from cotton, which uses land and water. In 2014, the number of garments produced globally amounted to nearly 14 new items of clothing per person.

In the EU, there are around 171 000 companies in the textile (including wearing apparel) industry, employing 1.7 million people. In 2017, the EU produced 7.4 kg of textiles per person while consuming nearly 26 kg. The EU is therefore a net importer of textiles (mainly finished products from Asia).

Exports from the EU mainly comprise intermediate textile products, such as technical fibers and high-quality fabrics in which the European industry specializes.

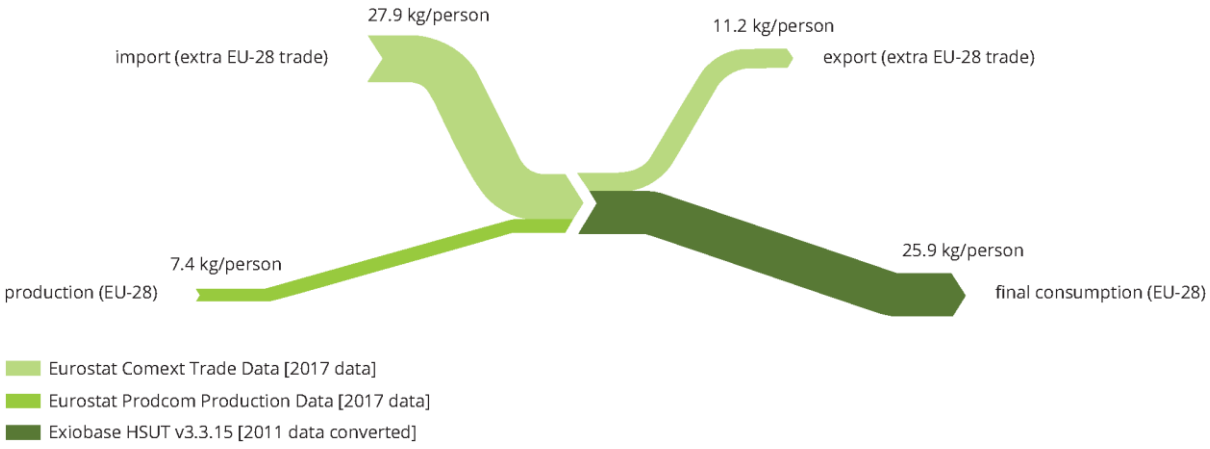


Figure 19 – Production, Imports, Exports and Consumption of textile products EU-28. Source: ETC/WMGE

Between 1996 and 2018, clothing prices in the EU dropped by over 30 %, relative to inflation. Since 2000, Europeans have purchased more pieces of clothing but spent less money in doing so. Fast fashion — the rapid changing of clothing lines and fashion

trends - promotes increased consumption and reduces the life span of clothing.

EU consumers discard about 11 kg of textiles per person per year. The export of used clothes — mainly to eastern European countries, Asia and Africa — is significant and increasing. Used clothes not exported are mostly incinerated or landfilled. Textiles recycling is low.

Resources Used

Regarding total use of primary raw materials in the supply chain for consumption in the EU, clothing, footwear and household textiles represents the fourth highest pressure category after food, housing and transport (Figure 20).

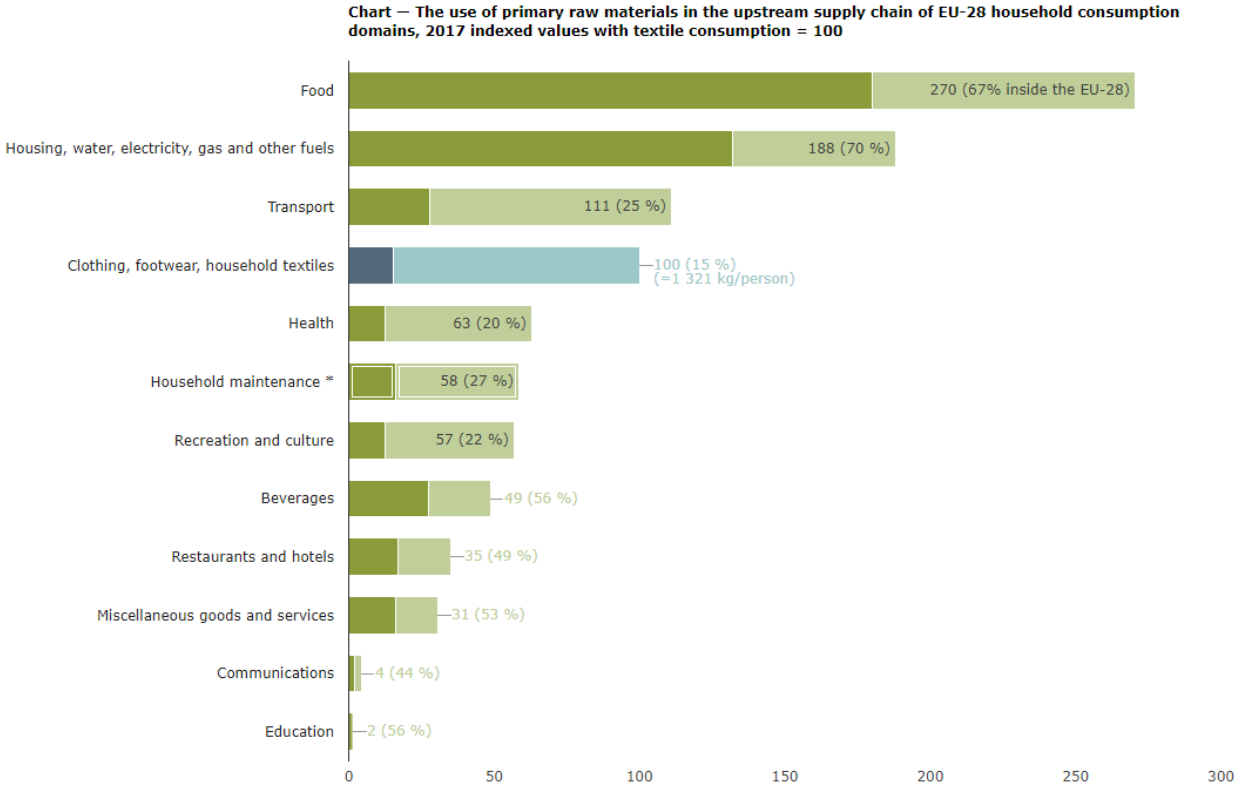


Figure 20 - Use of primary raw materials in the supply chain for consumption in the EU. Source: ETC/WMGE

Textiles are also the fourth highest pressure category for water use. Producing and handling all clothing, footwear and household textiles purchased by EU- 28 households in 2017 used an estimated 1.3 tonnes of primary raw materials and 104 m3 of water per person. Some 85% of these primary materials and 92% of the water were used in other regions of the world, which is highest of all consumption domains.

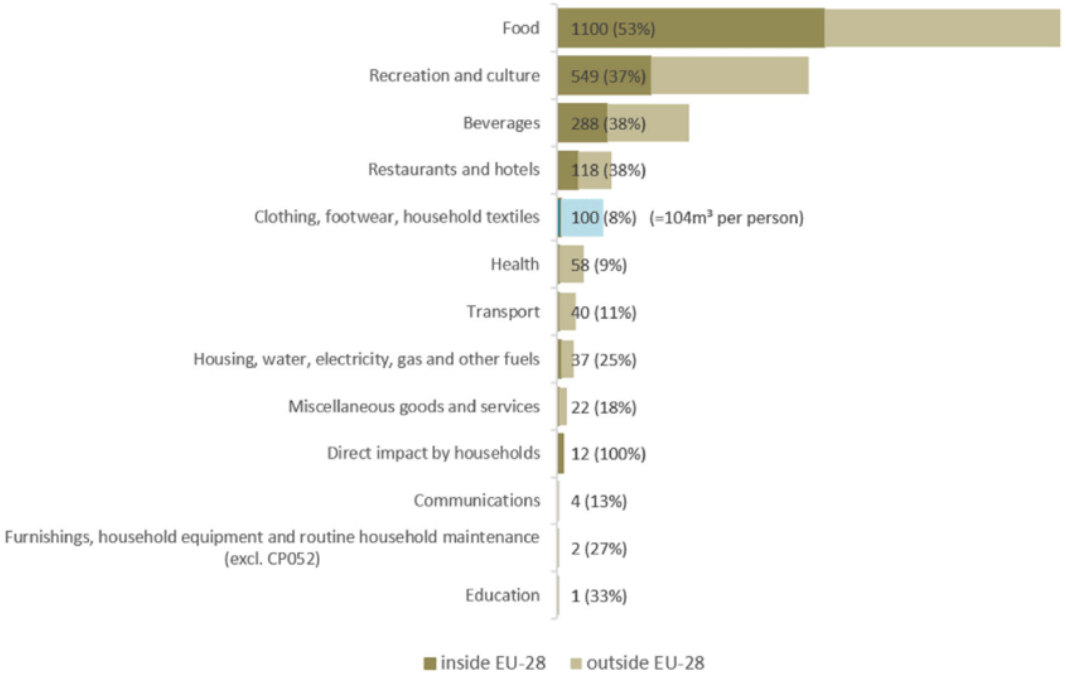


Figure 21 – Use of water in the production process cross different sectors in the EU. Source: ETC/WMGE

Land Use

Regarding pressures on land use from the upstream value chain for consumption in the EU, clothing, footwear and household textiles represent the second highest pressure category, following food consumed in the EU. The majority of pressures on land use come from outside the EU (93 %) and are largely a consequence of cotton cultivation.

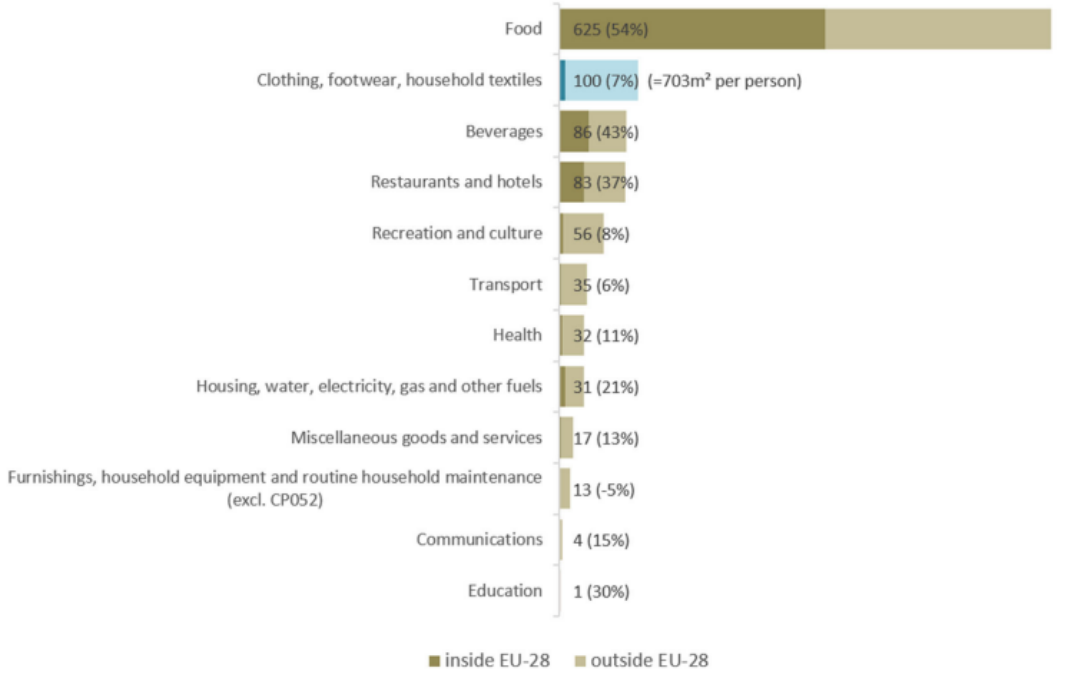


Figure 22 - Use of land in the production process across different sectors in the EU. Source: ETC/WMGE

Greenhouse Gas Emission

Looking at climate change pressures, the production of textiles generates around 15-35 tonnes of CO^2 equivalent per ton of textiles produced. The upstream value chain of clothing, footwear and household textiles consumed in the EU is the fifth highest greenhouse gas emission pressure category. Its contribution is higher than the following consumption categories (Figure 23):

- Recreation and culture;
- Beverages;
- Health;
- Restaurants and hotels;
- Communication.

The production and handling of clothing, footwear and household textiles consumed in the EU-28 generated emissions of 654kg CO^2 equivalent per person in 2017. Only 25% of this took place inside the EU-28.

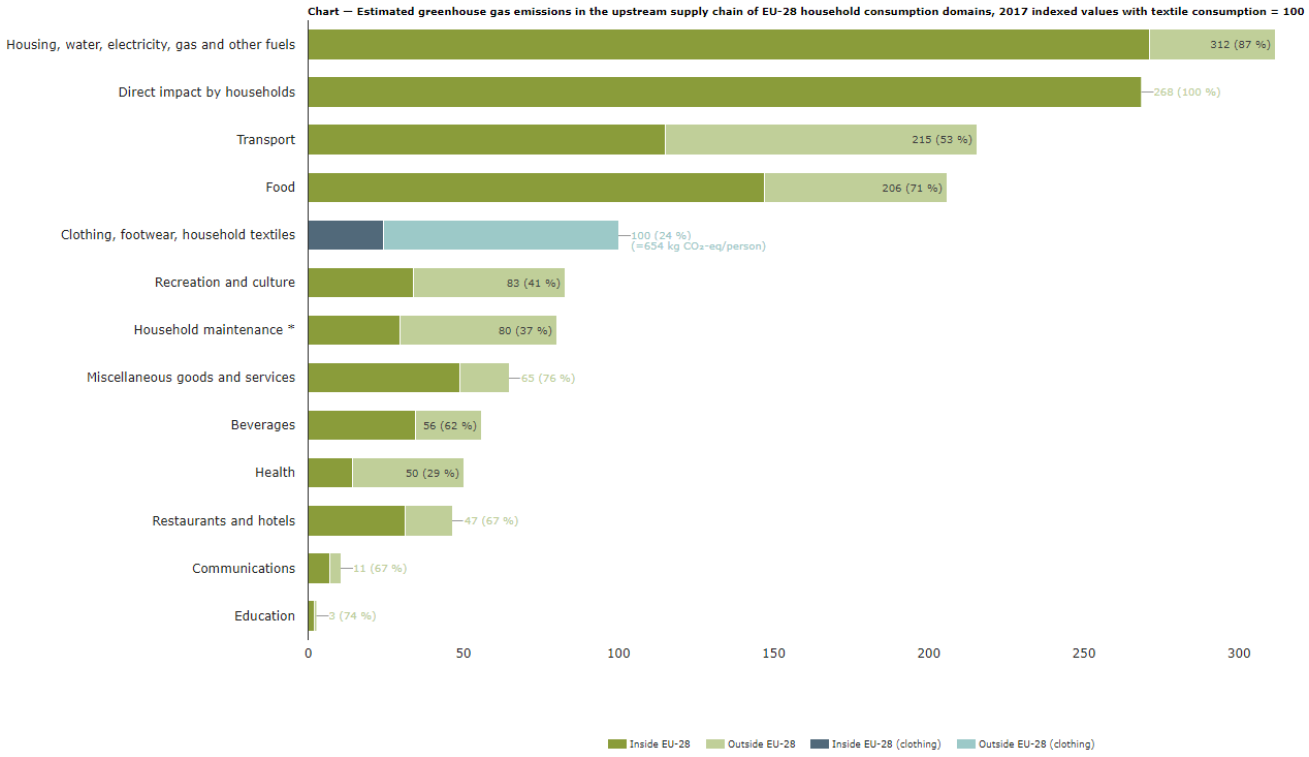


Figure 23 – Greenhouse Gas Emission in the production process across different sectors in the EU.
Source: ETC/WMGE

Chemical and Water Pollution

Textile production processes make use of a large amount and variety of chemicals. About 3.500 substances are used in textile production. Of these, 750 have been classified as hazardous for human health and 440 as hazardous for the environment. It is estimated that dyeing and finishing textile products, affecting the health of workers and local communities, cause about 20% of global water pollution.

Washing releases chemicals and micro plastics into household wastewater. It is estimated that about half a million tonnes of plastic microfibers are released into the ocean annually from washing plastic-based textiles.

Social Pressure and Impact

In addition to the environmental and climate effects, the highly competitive, mostly linear business models in the sector — inside and outside Europe — can have detrimental social impacts. These include poor salary wages, poor working conditions and poor equal conditions for men and women.

Avoiding suppliers outside Europe that use child labor is still a challenge in some regions.

In addition, High rate of industrial work related accidents, including fatalities, occur regularly.

2.1. CHALLENGES FROM THE ADVANCED MANUFACTURING

Sustainability, namely environmental sustainability is becoming a great concern from the society, and the public authorities are setting rigid decarbonisation plans that will affect the overall industry and manufacturing companies, namely the textile companies that are known for having a relevant impact on the environment. The challenge is now to find new business models, shorten the value chain and producing locally, creating recycled products and low-carbon production processes that can relieve the environmental impact caused by the textile production.

And the opportunity is now for the ones that are willing to grab it. The demand for greener products and processes from retailers and big fashion brands its just starting and it will become a “must have” rather than a “good to have” label. In this respect, European textile producers and Certification Bodies should pave the way towards a more rigid control that

can separate those that actually comply with the standards and those that claim to have it.

It is nearly impossible to predict what the future of the textile industry will look like 20 years down the road, but there is a certainty that Industry 4.0 will drastically change the way how the manufacturing businesses operate.

Like any other manufacturing segment, the Textile and Clothing industry is seeing the rise of more advanced and smarter technologies such as artificial intelligence, 3D printing, machine learning, big data, automation systems and more. The real-time monitoring of businesses allows a wide range of benefits from increased scalability to improved quality control, ensuring cost-effective and high-quality goods.

Industry 4.0 is now a generalized push toward more digital-focused and smarter processes, made possible with the help of modern technologies. If the European textile industry will not be able to move towards the digital transformation, like we're seeing all across the world, it will be difficult to stay competitive.

Consumer orientation is fundamental to understand what consumer needs and wants, anticipating production of items and goods that people are willing to buy. The viability of textile manufacturers, retailers and brands, is based on the ability to predict, develop, and communicate styles of apparel and other textile products that are in accordance with the consuming desires. Lately, it seems that a new trend starts to appear moving from a fast fashion consumer behaviour to a more conscious consumption of textile and apparel products.

Another finding is that consumers' awareness for sustainable products is increasing day by day and their interest in recycling and sustainable solutions has increased, meaning that remanufacturing processes and circular fashion chains should be created and communicated to consumers.

Additionally, climate change, resource scarcity and the impact of waste on the earth's ecosystems will also change manufacturing paradigms. Made in Europe will develop new technologies and methods for circular, low-environmental impact and low-carbon approaches while increasing energy and resource efficiency in manufacturing. Energy and power technologies will further enable resilient and sustainable manufacturing, by deploying integrated approaches which cover lifecycles and link different sectors, disciplines and ecosystems. In addition, new production systems and concepts will be needed when manufacturing increasingly uses recycled materials or when remanufacturing happens.

Any kind of sustainability and societal impact can only be achieved if manufacturing is competitive and is able to generate the income required to pay knowledge-workers and to invest in environmentally friendly and worker-friendly factories. Hence, economical sustainability is vital to realising any sustainability.

The availability and use of technology can enable the move towards the circular economy in the manufacturing industry. Managing the green transition will pursue the use of key enabling technologies, such us advance manufacturing and digital technologies towards[32]:

- Zero-defect and zero-downtime high-precision manufacturing, including predictive quality and non-destructive inspection methods
- Scalable, reconfigurable and flexible first-time-right manufacturing
- Manufacturing processes and approaches near to customers or consumers (including urban manufacturing)
- Transparency, trust and data integrity along the product and manufacturing life-cycle
- Virtual end-to-end life-cycle engineering and manufacturing from product to production lines, factories, and networks
- Digital platforms and data management for circular product and production systems life-cycles
- Collaborative product-service engineering for costumer-driven manufacturing value networks
- Digital platforms and engineering tools supporting creativity and productivity of manufacturing development

In addition, digital services alongside circular clothing will create additional value for consumers, following a trend that increased with the Covid-19, where consumers increased their online shopping experiences exponentially and are now taking this as a habit.

32 https://www.effra.eu/sites/default/files/sria_full_chapters.pdf

2.3. INITIATIVES TOWARDS A CIRCULAR ECONOMY

2.3.1. BUSINESS MODELS AND POLICY INSTRUMENTS

In the last decades, we observed the mass production industry shifting to countries with low labour costs. The European Textile and Clothing industry was probably the most affected sector due to the increasing low-cost business sourcing from overseas as the only way to compete with inexpensive products imports. European manufacturers understood that moving to cheap-labour countries would allow their businesses to stay competitive.

After covid-19, and after seeing the great dependency that Europe has from oriental countries, when it comes to low-cost products (facial masks or disposable health-related items), but also from high-tech products (chips produced by the semiconductor industries) from Asia, a new movement is now rising. That movement is the idea of defending that Europe needs to keep relevant activities in the region, not only for job creation but also to ensure that there won't be lack of relevant supplies that can threaten the European standards of living.

Further, the debate over whether offshore manufacturing is good for Europe, a new argument is now in place, related to the carbon footprint created when shipping goods overseas that could be produced locally in a closed value chain. In their rush to save money, managers often lose sight of the high penalties of moving abroad, namely the environmental impact that they are generating.

Private companies and public authorities are increasingly seeing the potential economic, social, environmental and climate benefits of a circular textiles system. Recently, circular business models focusing on circular textile design, sharing, recycling and reuse of textiles have surfaced. Such business models cannot be isolated upscaled — it needs a change in the whole system supported by regulation and other policies.

In 2019, the European Commission identified textiles (apparel and fabrics) as a 'priority product category for the circular economy' in Sustainable products in a circular economy - towards an EU product policy framework contributing to the circular economy. Furthermore, the new European Commission President announced in My agenda for Europe that she 'will propose a new circular economy action plan focusing on sustainable resource use, especially in resource intensive and high-impact sectors such as textiles and construction'.

Education and behavioral change are an important part of the shift towards circular textiles to bring about behavioral change across the entire system — from production

and processing to transport, consumption and waste.

The Ellen MacArthur Foundation describes a circular textiles system as one that is:

…restorative and regenerative by design and provides benefits for business, society and environment. A system in which clothes, fabrics and fibres are kept at their highest value during use, and re-enter the economy after use, never ending up as waste.

The EEA envisages the circular economy as one in which circularity is ensured in all phases of the lifecycle, including materials, eco-design, production and distribution, consumption and stock, and waste. It did so most recently in the 2019 EEA report paving the way for a circular economy: insights on status and potentials.

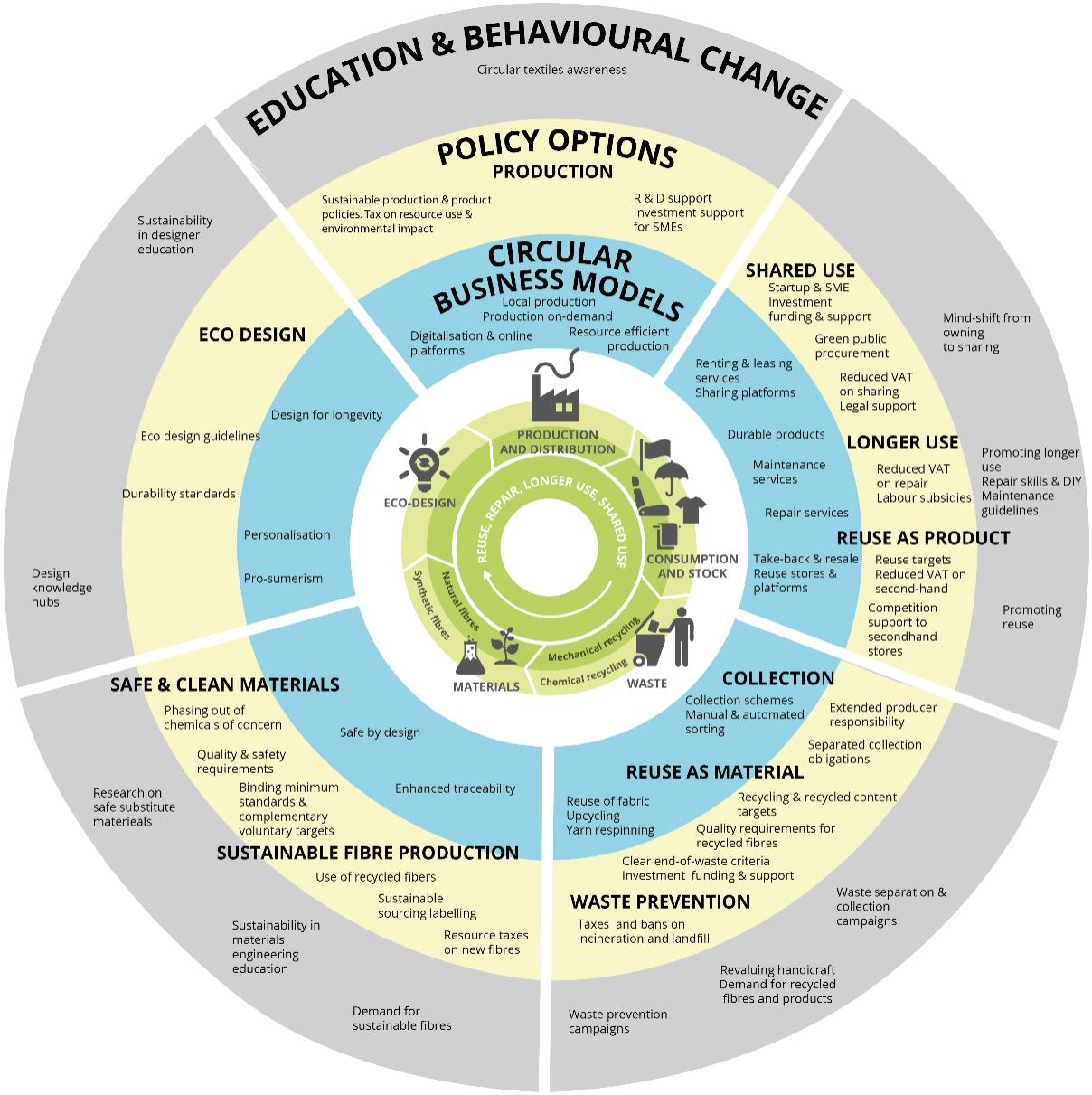


Figure 24 – Education & Behavioural Change. Source: ETC/WMGE

The choice of materials and the design influence the environmental and climate impacts of textiles and the end-of-life options available in future. Circular business models need to be systematically scaled – and supported by policies - to enable sustainable sourcing of synthetic and natural fibers, including recycling and reuse of materials. When creating a circular economy for textiles, design choices are key. Safe and clean material cycles can be supported by:

- Regulation and policy options targeted at quality and safety requirements;
- Public demand for sustainable fibres;
- Labelling and standards.

Resource taxes on new fibers could potentially increase the demand for used fibers. A strong focus on sustainability in design education curricula would be a powerful spur for a change in design culture. Extended producer responsibility is an option already used in other sectors to make producers responsible for the materials used throughout their whole lifecycle.

Mainstream business models often rely on short production and consumption cycles and low-cost labor and materials, generating social and environmental impacts. Circular business models should be systematically scaled and supported by policies, in order to ensure a more sustainable production in terms of:

- Fair working conditions;
- Fewer emissions;
- Resource efficiency;
- Safe chemical use;
- Communication standards to customers through labelling.

Waste and overproduction should be avoided, e.g. by shifting towards on-demand production. Policy instruments, such as harmonized product standards, efficiency requirements and labels, can support this shift.

In the use phase, business models should encourage collaborative consumption and longer use, e.g. by supporting leasing rather than buying, sharing platforms, take-back and resale, and second hand stores, and by revaluing repair and maintenance. Economic policy instruments — e.g. in the form of taxes, levies or value-added tax (VAT) adjustments — offer an opportunity to reduce virgin material use per capita and influence market dynamics in favor of sustainable textiles and repair services.

Increasing the use of green public procurement of textiles could pave the way for scaling

up circular business models and increased awareness in society. Education of consumers and the use of labelling, plays an important role in encouraging more sustainable textile use, such as reduced consumption, longer use and better maintenance (e.g. by reducing washing temperatures and avoiding tumble drying).

In the collection, recycling and waste treatment stages, it is important that circular business models enable recycling and reuse. Investment is needed to ensure sufficient capacity.

EU policies oblige Member States to:

- Collect textiles separately by 2025;
- Ensure that waste collected separately is not incinerated or landfilled.

Policies also encourages setting up systems for repair and reuse of textiles to prevent waste in the first place. EU and national policymakers could consider future waste management targets, extended producer responsibility, collection and take-back schemes.

Circular business models supported by regulation and other policies should not only be aimed at circularity on a small scale but also spur systemic change within the whole textiles system towards a circular economy, fueled by sustainable and safe materials and products.

Overall, we can observe 4 main business model types **in the textiles system**, each supporting the shift towards a circular textiles system:

- **Longevity and durability:** selling durable textile products, focused on delivering longer product lives, for example, by using sturdy, high quality materials and repairable designs.
- **Access-based models, based on renting and leasing (business-to-business/business- to-consumer) or sharing (mostly consumer-to-consumer):** the textile products remain in the ownership of the company running the system, while the customer pays for having access to them.
- **Textile collection and resale:** business models related to resale, focusing on extending the useful life of textiles beyond the first user;
- **Recycling and material reuse:** this model focuses on closing the loop for textiles, by turning waste textiles into raw materials for new production chains.

Each of these four pathways tap into different societal opportunities but face different

systemic challenges. Specific opportunities and challenges related to business models, social and technical innovation can be highlighted for each pathway. This creates a new perspective on the possibilities and limitations of business model innovation in driving the transition to a circular economy. It makes clear which action is needed to mainstream a certain type of circular business model. Equally important, it also shows that different pathways can be useful, depending on the technical, social and policy context.

In 2025, there will be a fully globalized economy serving an informed and prosperous global middle class that will require personalized goods and services based on advanced manufacturing systems enabled by ICT and supplied by resource efficient and sustainable industries in Europe[33].

Policies to adapt to and mitigate climate change, will also create pressure on energy use, driving energy efficiency and a move away from fossil fuels.

Today, the European textiles industry is largely dependent on imports for both synthetic and natural fibers, especially cotton. In the future, as world population grows, the demand for raw materials and food will increase, increasing competition not only on markets for fibers, but also for land. This will affect EU textiles material supply and incentivize optimum use of local resources, either through the use of bio-based man-made fibers, alternative natural fibers such as wool and linen, or through recycled textiles.

By 2025 the textiles and clothing industry, including fiber-based materials, clothing, home and technical textiles, will be a strategic EU industry sector providing innovative and competitive products enabling personalized, adaptable and attractive solutions, integrating services for very diverse, informed and demanding consumers and businesses.

It will operate according to a globalized and efficient circular economic model that maximizes the use of local resources, exploits advanced manufacturing techniques and engages in cross-sectorial collaborations and strategic clusters. It will implement profitable and inclusive business models and attract skilled and talented entrepreneurs and employees.[34]

REACH – applies to all chemical substances

The most rigorous EU chemicals regulation is Registration, Evaluation and Authorisation of Chemicals, REACH (EC No 1907/2006): In principle, REACH applies to all chemical

[33] https://ec.europa.eu/jrc/sites/jrcsh/files/fta2014-t1_practice_167.pdf
[34] https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX%3A32018L0851

substances; not only those used in industrial processes, but also in our day-to-day lives, for example in cleaning products and paints, as well as in articles such as clothing, furniture and electrical appliances. Therefore, the regulation has an impact on most companies across the EU, and the production of secondary raw materials must comply with REACH.

REACH places the burden of proof on producing companies to demonstrate that their substances can be safely used, and to communicate risk management measures to users. If risks cannot be managed, authorities can restrict the use of substances through either Annex XIV (authorization) or Annex XV II (restriction). When a substance of Very High Concern (SVHC) is placed on REACH Annex XIV, authorization is required for continued use within the EU.

An authorization will only be granted if the risks can be controlled, or if there are no alternatives and the socioeconomic benefits are higher than the costs of using the specific substances. The authorization is time-limited and granted to a specific company for a specific use. Authorizations can apply to substances in recycled materials. However, the procedure does not address imported articles.

Restrictions in REACH apply to all companies and products produced within the EU, as well as products imported into the EU. A restriction is set for a specific use of a specific chemical. Derogations (exceptions) from the restriction might be included in the decision, for example for recycled materials. These are time-limited.

REACH may be subject to a review, scheduled for 2022.

Waste framework directive (WFD) – clarifies the distinction between waste and materials

Directive (EU) 2018/851[39]: The WFD sets the basic concepts and definitions related to waste management and lays down some basic waste management principles.

One such element is the end-of-waste criteria, which specify when waste is no longer to be seen as waste, but obtains the status of a product or secondary raw material.

However, the existing criteria are only set for three categories:

- Iron, steel and aluminum scrap
- Glass cullet
- Copper scrap

The Commission is to prepare a set of end-of-waste criteria for additional priority waste

streams. However, this work has been ongoing for a long time and it has proved to be very difficult to reach agreements on the criteria for materials such as plastic.

In the policy debate around circularity for textiles a number of policy options or actions are frequently discussed such as: Extended Producer Responsibilities (EPR) schemes, Eco-design, implementation of separate textile waste collection, centralized database[35] on data over harmful chemicals, others. In some cases, different interpretations and reasoning behind the same wording may apply.

"Extended Producer Responsibility" (EPR) aims at ensuring that producers contribute financially to the costs of waste management. Indeed, EPR obliges producers to take operational or financial responsibility for the end-of-life phase of their products. EPRs then become an economic instrument to stimulate better design and reduce such costs.

The European Union regulated EPRs in the 2018 Waste Directive, which introduces minimum requirements for the Member States to establish EPRs, in the sectors and cases they see it fit.

2.3.2. EUROPEAN PROGRAMS

European Green Deal

Although there is only one planet Earth, in 2050, we will be consuming as if there were 3. The global consumption of materials such as biomass, fossil fuels, metals, and minerals is expected to double in the next forty years, while the annual generation of waste is expected to increase by 70% by 2050. About half of the emissions of greenhouse gases and more than 90% of the loss of biodiversity and water stress result from the extraction and processing of resources. As a result, it is estimated that one million of the eight million species on the planet are at serious risk of being lost.

The European Green Deal appears this way in response to all these current challenges. It is defined as a new growth strategy that aims to transform the European Union (EU) into a fair and prosperous society, with a modern, resource-efficient, and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from the use of resources. It is also an integral part of the European Commission's strategy to implement the United Nations 2030 Agenda and sustainable development goals.

[35] European Chemical Agency (ECHA) SCIP Database (https://echa.europa.eu/scip-database)

It provides a roadmap with actions to boost the efficient use of resources, moving to a clean and circular economy, reversing the loss of biodiversity, reducing pollution, and halting climate change. It also describes the investments needed, the financing tools available, and explains how to ensure a fair and inclusive transition.

The industry in Europe has already started to change but is still responsible for 20% of the EU's greenhouse gas emissions. This industry remains very "linear" and dependent on a flow of new materials extracted, traded, and processed into goods and, finally, discarded in the form of waste or emissions-only 12% of the materials used come from recycling. Consequently, one of the new policy framework's main objectives will be to stimulate the development of pilot markets for circular and climate-neutral products inside and outside the EU. To achieve a circular and climate-neutral economy, total mobilization of the industry will be required. Several decisions and actions will have to be taken in the next five years to achieve the goals defined for 2050. The expansion of the circular economy will not only make a decisive contribution to achieving climate neutrality by 2050 but also to decouple economic growth from the use of resources while ensuring greater EU competitiveness in the long run (European Commission, 2019).

Circular Economy Action Plan

The Circular Economy Action Plan establishes a future-oriented strategy, intending to create a more competitive and cleaner Europe in association with economic agents, consumers, citizens, and civil society organizations. It plans to accelerate the European Green Deal's transformative change based on the actions developed in the field of the circular economy since 2015. It ensures a flexible regulatory framework adapted to a sustainable future, allowing the maximum benefit of new opportunities arising from the transition and minimizing the charges on businesses and citizens.

It includes a set of related initiatives to establish a coherent and solid strategic framework, in which sustainable products, services, and business models are the norm and in which there is a transformation of consumption patterns to prevent the generation of waste.

Its political product structure will be implemented progressively, while the leading product value chains will be treated as a priority issue. The EU's capacity to take responsibility for its waste will also be strengthened.

The plan also aims to ensure that the circular economy is at the service of people, regions, and cities, fully contributing to climate neutrality and harnessing the potential of

innovation, research, and digitalization (European Commission, 2020a).

Member States: Research and Innovation Strategy for Smart Specialization 2014-2020

In a context of significant economic challenges that Europe faces, such as the growing international competitive pressure and the evident stagnation of the European Union economy, an ambitious economic policy with a new strategic direction for the 21st century is required. This strategic direction is outlined in the Europe 2020 Agenda and aims to tackle structural weaknesses through progress on three mutually reinforcing priorities:

- Achieve smart growth - Develop an economy based on knowledge and innovation;
- Achieve sustainable growth - Foster a more efficient economy in the use of its resources, becoming more ecological and competitive;
- Achieve inclusive growth - Promote an economy with high employment levels, ensuring social and territorial cohesion.

As part of the Europe 2020 Strategy, the Commission adopted the Innovation Union, which establishes a comprehensive innovation strategy to increase Europe's capacity, intending to provide smart, sustainable, and inclusive growth. The concept of smart specialization appears as a way to achieve these goals. Firstly, smart specialization is essential for the future of Europe, as the development of an economy based on knowledge and innovation remains a fundamental challenge for the European Union as a whole. Second, smart specialization is vital to achieving sustainable growth in the form of the investment required to move to a resource-efficient, low-carbon economy while still offering domestic and global markets opportunities. Finally, smart specialization contributes to inclusive growth within regions, as it allows strengthening territorial cohesion, through the creation of economic opportunities and investment in skills development, better jobs, and social innovation.

In the context of this new cohesion policy, smart specialization was proposed as an "ex-ante conditionality". This means that all Member States and regions, to receive financial support from the European Union for their planned innovation measures, must have a well-developed strategy.

To fulfill this ex-ante conditionality, the Member States have developed and submitted to the European Commission their Research and Innovation Strategies for Smart Specialization, that usually have a National and Regional level.

2.3.3. MACRO-TENDENCIES DRIVING THE CIRCULAR ECONOMY

Climate Change

Companies start their production processes by extracting materials from the earth, then applying energy and labor to manufacture a certain product, which is then sold to an end-user, who will ultimately discard it when it no longer serves its purpose. This linear take-make-dispose approach is characteristic of our current economic model. It depends on fossil fuels, does not manage resources properly in the long term, and it is responsible for the emission of greenhouse gases (GHGs), which are causing a global climate crisis (Ellen MacArthur Foundation, 2019).

The rapid growth of the population also emerges as a worrying trend. In the next 30 years, it is estimated that the global urban population will grow by about 2.4 billion. This population increase will result in a significant expansion of existing cities and the construction of new ones, and, associated with the construction and support of urban lifestyles, cities use billions of tons in material resources, from fossil fuels, sand, food, wood, among many others.

In this way, it is predicted that the increase in demand for raw materials will increasingly contribute to climate change and may even reach the point where what the planet can provide sustainably is exceeded (European Commission, 2020b).

The most significant long-term risks to the global economy are already related to climate change (World Economic Forum, 2016). The global economic damage was estimated at USD 54 trillion in 2100 for an increase of 1.5º C above pre-industrial levels and could increase to USD 69 trillion, with a rise in 2º C (IPCC, 2018). In this way, unless we can unlink the growth from environmental impacts, humanity will face an ecological crisis with profound effects (Gower & Schröder, 2016).

To meet the established climate goals, we will need a fundamental change in our economic model. This requires a shift from the current linear economic model to a regenerative economy by design (Circular Economy). In this economy, natural systems are regenerated, energy comes from renewable sources, materials are safe and come from renewable sources, and waste is avoided through the design of materials, products, and business models. Thus, the circular economy offers a positive path by redefining value creation, focusing on the benefits of society. The circular economy principles present unique opportunities to help tackle climate change by reducing GHG emissions along the value chains, preserving the energies incorporated in products and materials, and increasing carbon sequestration through natural systems' regeneration.

Previous reports prepared by the Ellen MacArthur Foundation showed that in Europe, India, and China, a circular economy, when implemented in sectors such as construction, mobility, food, electronics, and textiles, would be able to reduce GHG emissions by 22-44% by 2050 (Ellen MacArthur Foundation, 2019). Also, in the work “Implementing Circular Economy global makes Paris target achievable,” it was demonstrated that the current national commitments would only reach about half of the required emissions cuts and how the circular economy can fill about half of the remaining gap (Figure 25) (Blok et al., 2016).

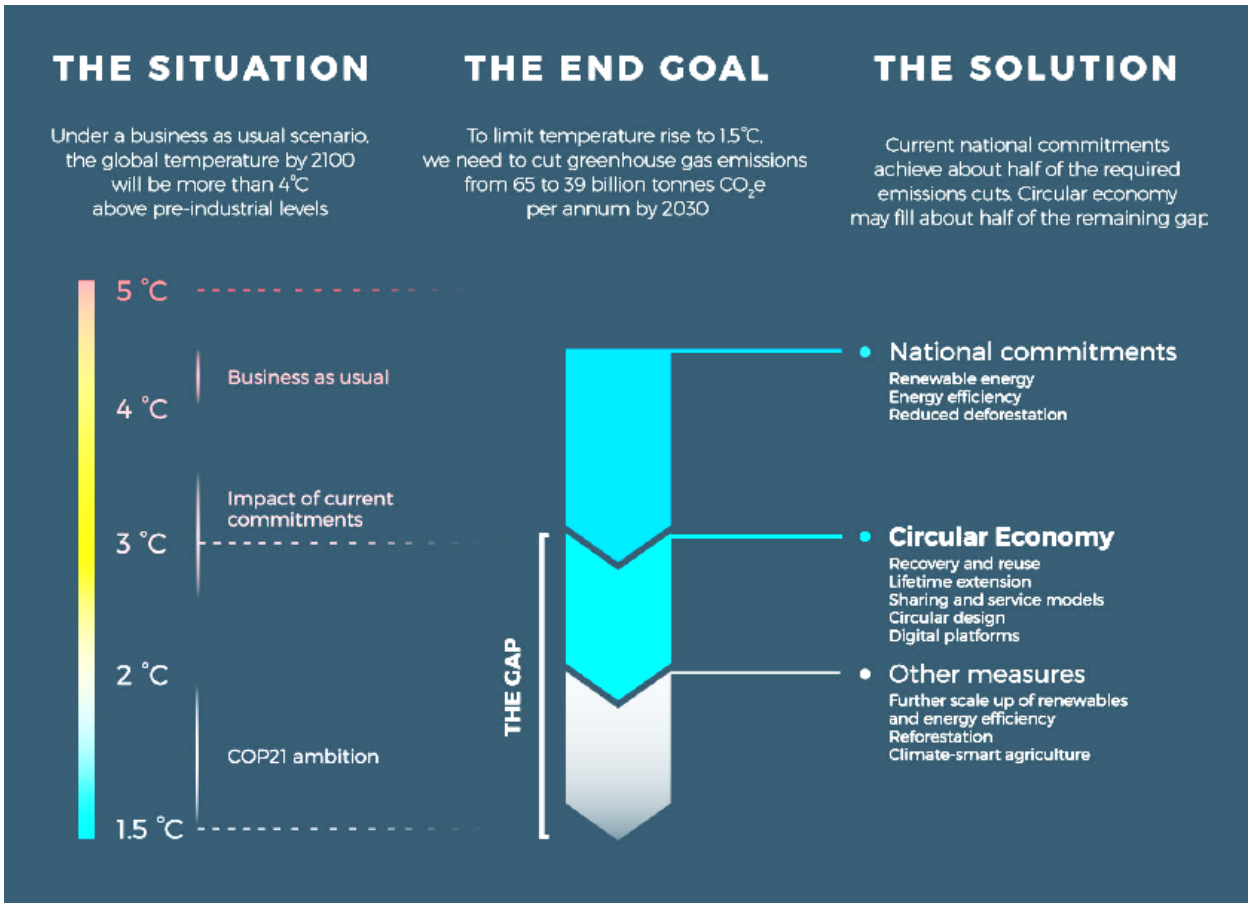


Figure 25 - Estimation of the contribution that the circular economy can make to reduce emissions.
Source: Report "Implementing Circular Economy globally makes Paris targets achievable"

Industrial Symbiosis

Industrial Symbiosis can be defined as a collaboration between companies from different sectors to generate competitive advantages by exchanging materials, energy, and water. About waste, to make the flow of energy and materials cyclical, industrial symbiosis allows waste to be re-inserted into the value chain as by-products after its production.

A by-product is a substance or object resulting from a production process, whose main objective is not its production, so the waste that is produced by certain companies may be the by-products of others (BCSD, 2018).

Industrial Symbiosis Opportunities:

- Creation of new business opportunities;
- Job creation;
- Exchange of by-products between companies;
- Sharing the management of common services: water, energy, and waste;
- Leverage of industrial parks;
- Collaboration between stakeholders within a region;
- Cost reduction: reduced consumption of raw materials, sharing of waste management infrastructures;
- New revenue from the sale of waste and by-products;
- Environmental benefits: reduced use of virgin raw materials and reduction of CO2 emissions.

Industrial symbiosis creates an interconnected network that intends to operate in a similar way to ecological systems' functioning, within which materials and energy circulate continuously without the generation of waste. This process is thus able to reduce the environmental footprint of the industries involved.

Not so many virgin raw materials are needed, and the need for waste disposal in landfills is also reduced. It allows the creation of value from materials that would otherwise be discarded, and, therefore, the materials remain with economic value for longer than in traditional systems (Sommer, 2020).

In a developed economy with many industrial activities, several different by-products are generated, and therefore, the range of potential uses for these by-products is equally diverse. This is where structured industrial symbiosis programs must come into play. However, these involve approaches that bring companies together in innovative collaborations, finding new ways to use resources and thereby increase their revenues while reducing waste and associated costs (Europa, 2014). In this way, the application of industrial programs promotes the use of materials in a sustainable way and contributes very significantly to the promotion of the circular economy (Sommer, 2020).

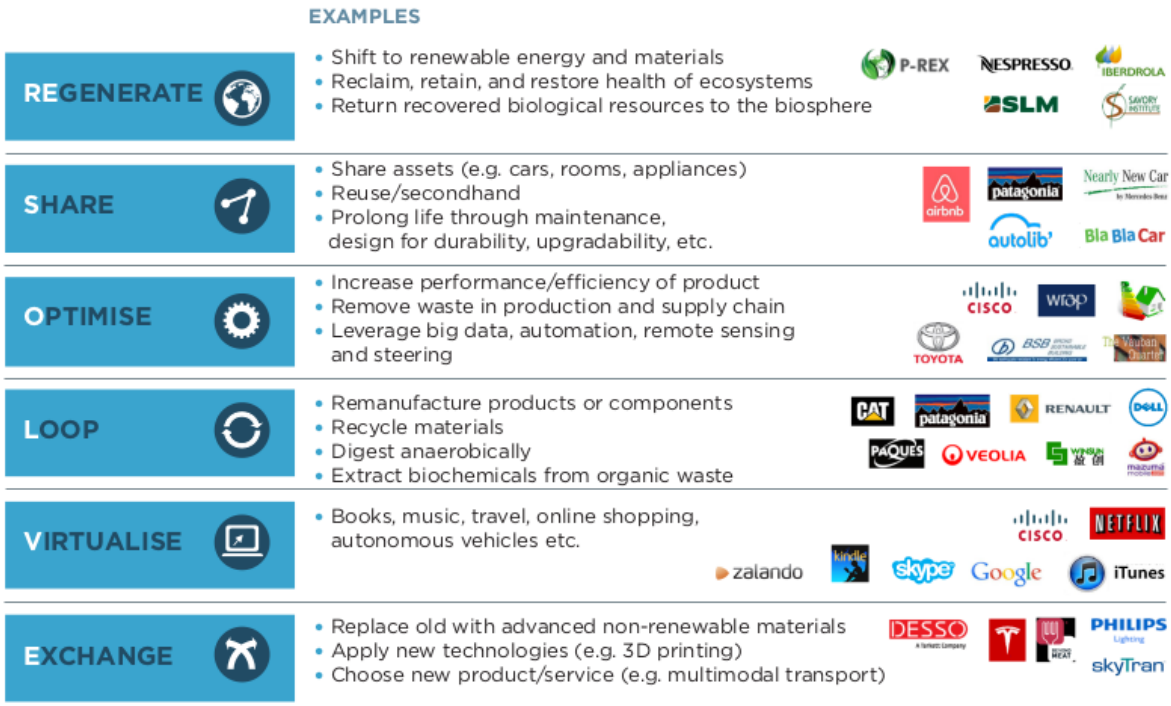
Technology

There is a consensus regarding the critical role of digital technologies in the transition to a circular economy (Ellen MacArthur Foundation, 2015; European Resource Efficiency Knowledge Centre, 2019; Pagoropoulos et al., 2017). According to the European Resource Efficiency Knowledge Centre (2019), the promotion of digital transformation linked to the circular economy corresponds to an area with high potential. Companies have increasingly recognized this since they can lead the transition to a circular economy efficiently and quickly through the adoption of innovative technologies. Many of them are already taking advantage of the potential associated with the latest technologies to project pollution and waste out of their value chains while simultaneously keeping products and materials in use, thereby creating a positive environmental, economic and social impact (Hussain & Sullivan, 2020).

In the report "Growth within a circular economy vision for a competitive Europe," prepared by the Ellen MacArthur Foundation, a study was carried out which, based on the three principles inherent to the circular economy:

- Foster system effectiveness;
- Preserve and enhance natural capital by controlling the stock of finite resources and balancing the flow of renewable resources;
- Optimize resource yields through the circulation of products, materials, and components in use with the greatest utility at various times.

Six business actions were identified, each of which represents a great circular business opportunity made possible by the technological revolution. Figure 26 shows the respective actions and examples of some companies that are already practicing these same actions.



Source: Company interviews; Web search. S. Heck and M. Rogers, *Resource revolution: How to capture the biggest business opportunity in a century*, 2014.

Figure 26 - Six Circular Business Opportunities enbaled by the Technology Revolution
Source: Report: "Growth within: A circular economy vision for a competitive Europe"

By integrating these new technologies and business models applying the circular economy's principles in the European economy, it is possible to maximize the value extracted from the stocks of assets and materials, thus achieving internal growth. Proof of this was the data that mentioned that a circular economy, made possible by the technological revolution, would allow Europe to increase resource productivity by up to 3% per year. This would generate a primary benefit of € 0.6 trillion per year until 2030. It would also generate € 1.2 trillion in non-resource and externality benefits, thus bringing the total annual benefits to around € 1.8 trillion compared to today (Ellen MacArthur Foundation, 2015).

Although all these trends referred in this chapter have played an essential role in implementing the circular economy, there are still several barriers that must be overcome to allow more companies to be willing and ready to make a shift towards a circular economy (European Resource Efficiency Knowledge Centre, 2019). Because until today, little progress has been made concerning its implementation (Kirchherr et al., 2018).

2.3.4. BARRIERS TO THE IMPLEMENTATION OF THE CIRCULAR ECONOMY

There are still some barriers that hinder the progress of the transition to a circular economic model. Each of these constitutes, in itself, an adversity to the implementation of the circular economy. However, the multiple interactions between the different types of barriers can also be sources of chain reactions and contribute to the transition failure (Kirchherr et al., 2018; Ritzén & Sandström, 2017).

In this chapter, we will address the financing and political structure barriers, as these, in addition to being barriers to the implementation of the circular economy, are areas that will also play a key role in the immediate response to the crisis caused by the Covid-19.

Financing

Finance plays a crucial role in building a healthier, more resilient, and sustainable future. The circular economy's dimension helps in this process, since it promotes unlocking new and better growth opportunities for companies during the transition. However, for such a shift to occur, it is not enough to finance perfectly circular companies or to move away from extractivist to achieve climate goals and build a more resilient economy. This transformation will require a change in all sectors (Ellen MacArthur Foundation, 2020b). All financial aspects will also play a crucial role in an immediate response to the Covid-19 crisis and for a recovery phase.

The sudden and dramatic loss in demand and revenue caused by the pandemic, made several companies, especially small and medium-sized companies, face severe liquidity shortages. Therefore, public financial support will have an essential role in helping these companies, with the objective of their recovery or even their survival. Although there has been a response from policymakers in the European Union, with an increase in budgets for direct public support mechanisms and subsidies to small and medium-sized enterprises, many of these only focus on short-term liquidity needs. However, there are opportunities for more robust and more resilient long-term contracts to be shaped, and to that end, schemes must be restructured. For example, schemes can be provided to companies to help them implement circular economy principles, improve their environmental performance, competitiveness, leverage digital technologies, and strengthen their resilience against future shocks.

A tax system is a powerful tool for shaping economic activity and combating systemic issues that already prevailed, even before the Covid-19 pandemic. In addition, it can provide a favorable environment for the promotion of a circular economy. As mentioned above, the current crisis presents opportunities for governments to shape, in the long

term, a more prosperous economic recovery that meets environmental objectives. In particular, the OECD emphasized that reducing taxes on labor and capital, in favor of taxing environmentally harmful production and consumption, can play an important role in stimulating the creation of investments and jobs. This change in taxes can promote the valorization of resources and encourage circular business models of labor-intensive, such as maintenance, repair, and recycling.

Besides, specific fiscal support can also play a key role in stimulating innovation and encouraging circular economy practices. For example, tax breaks, such as value-added taxes on remanufacturing, reuse, and repair activities, can encourage circular projects and business models and support the circulation of valuable goods, nutrients, and materials (Ellen MacArthur Foundation, 2020c).

In the work “Financing the Circular Economy- Capturing the opportunity” prepared by the Ellen MacArthur Foundation, the following overview of the actions necessary to scale the financing of the circular economy was summarized:

1- **Governments, central banks, and financial regulators:**
   - Invest in activities, innovation, and infrastructure;
   - Improve transparency based on standardization and reports;
   - Integrate circularity in financial regulation and risk assessments;
   - Provide economic incentives.
2- **Financial services sector:**
   - Innovate to overcome barriers and close financing gaps, such as loans linked to circularity and bank loans for circular models that are difficult to finance;
   - Integrate the circular economy in strategies, goals, and decision making in all business lines;
   - Schedule circular economy financial products and services;
   - Formalize the circular economy through financial tools and structures, such as circularity measurement, credit approval processes, and circular security structures.
3- **Combined financial market:**
   - Provide technical assistance and advisory services to enable the financing of challenging projects;
   - Use a combined financing mechanism to reduce investment risk and attract private sector capital.

Political Structure

As economies recover from the pandemic crisis, inevitably reshaping global trade and value chains, the inclusion of circular economy practices in trade policies will be an essential area for future development. This was stated, since the circular economy presents a set of solutions for the separation of resource use and environmental impacts from economic growth. This can thus help to define a path for economic recovery that is low in carbon and more resilient.

However, to ensure that circular economy practices are integrated into trade policies, greater policy coherence will be needed (Ellen MacArthur Foundation, 2020c).

Whether at the national, multilateral, or regional level, government intervention is recognized as essential concerning the transition to a circular economy (Ellen MacArthur Foundation, 2020c; European Commission, 2020b; OECD, 2020). According to the European Commission (2020b), this intervention must consist of the following actions:

- Mobilization of the private sector and other stakeholders, such as consumers;
- Mobilization of investments;
- Facilitate trade in sustainable products;
- Increased awareness;
- Develop policy frameworks to provide security for economic operators in the longterm.

We also need coherent measures in many relevant policy areas, such as trade, industrial development, investment and finance, research and innovation, education, and entrepreneurship (European Commission, 2020).

Over the past few decades, an increasing number of local and national governments, recognizing their fundamental role, have begun to develop strategies and policies to awaken the transition to circularity and a more resource-efficient economy. In general, the principles of material circularity and resource efficiency - including resource productivity, material recovery, the “3 R´s” (Reduce, Reuse and Recycle) and sustainable materials management, started to guide local, sectoral, and national policies, increasingly focused on the entire life cycle of products and materials. Governments have also started combining solutions such as Green Public Procurement and Extended Producer Responsibility and a variety of regulations, instruments, and political information based on the market. This was also supported and encouraged by various multilateral and international initiatives, within the OECD, the European Union, the United Nations, and the G7 and G20. However, while there has been a progressive increase in

local, national, and international authorities' commitment, more efforts are needed to achieve a more resource-efficient circular economy (OECD, 2020).

Considering that policy responses have already been given to address the circular economy and resource efficiency, it is also necessary to mention the need to adopt stronger policies to improve the share of materials that are kept in the economy, to slow the growth of use materials, and change the mix of materials to more environmentally efficient materials. In this context, in the work “The circular economy: a transformative Covid-19 recovery strategy” prepared by the Ellen MacArthur Foundation, the following four main policy recommendations were highlighted:

1- **Promote resource efficiency throughout the product life cycle-** Promote more efficient use of natural resources, products, and materials, incentives to produce and use products with longer duration, minimize the extraction of raw materials and waste. Increase recycling, repair, reuse and remanufacture of materials and, finally, improve the treatment and classification of materials at the end of their useful life.

2- **Strengthen policy development through better data and indicators-** Evidence on material flows, environmental impacts, and resource efficiency is strictly necessary for building sustainable management of material resources, as well as to support the development and implementation of policy measures.

3- **Align sector policies with resource efficiency objectives**- Policy misalignments are often associated with inefficient incentives for the transition to the circular economy. For this challenge to be managed, national and international political structures need to integrate resource efficiency and transition to the circular economy comprehensively. Most notably, cross-cutting policies, such as education, investment, and innovation strategies, must integrate resource efficiency objectives. More particularly, support for innovation in small and medium-sized enterprises can help to decouple economic growth from the use of materials.

4- **Improve international cooperation-** Given the increasing globalization of value chains and the cross-border nature of resource flows, international cooperation is strictly necessary to ensure sustainable policy and benefits coordination for all.

3. INDUSTRY 4.0 AND DIGITALIZATION

3.1. CONCEPTS OF INDUSTRY 4.0 AND DIGITAL TRANSFORMATION

In order to establish a common ground on top of which it is possible to discuss the importance and the impacts of digitalization on advanced manufacturing and textile industries, it is important to organize the terminology and the concepts used when addressing the issues of digital transformation and Industry 4.0, among others. Not only different terms are used as if they were synonyms, but it is also frequent to see different meanings to the same terms. The use of the expression "Industry 4.0" (I4.0) has its origins in Germany, in the early 2010 decade, when the term was applied within the scope of the German government policies to transform its manufacturing sector, with the purpose to increase its competitiveness in the global world. This transformation views a factory as a network of assets, such as machines, facilities, workers and the products themselves, all connected together by a digital infrastructure, with the expectation to raise the industrial capacity to unprecedented levels of production, optimisation, efficiency and autonomy, while at the same time developing new and innovative business models. This future scenario has led to the consideration that we are facing a new industrial revolution, the fourth industrial revolution.

In brief, the history of the industrial revolutions establish a first industrial revolution due to the use of steam for mechanisation, with the well-known impacts on the textile industry of the United Kingdom, at the end of the 18th century. The second revolution is characterized by the paradigm of mass production, assembly lines and the use of electricity as a primary source of energy. The third industrial revolution was stamped by automation, electronics and the introduction of the computer. Having reached the fourth revolution, what distinguishes it from the previous is more diffuse and coined with new terminology.

This fourth revolution builds on the top of the results from the previous ones, namely the third industrial revolution, with the innovations and developments achieved in the fields of electronics, automation, computers and, finally, in communications. In this current revolution, cyber-physical systems and the internet of things were two terms that quickly emerged as the main technological drivers. These terms allude to the widespread use of sensors capable of measuring mechanical or electrical phenomena, and the transmission of that information to computers capable of high performance processing. In these scenarios, it will be possible to have real-time information about all the manufacturing equipment in a shop floor, all the road vehicles or all the machines sold and used by customers. This collected information can then feed alert systems that

detect anomalous situations, even before they reach critical levels, or reconfigure equipment autonomously, or even allowing a complete autonomy of systems and machines.

At the same time, it is in the context of an abundance of data that data science gains prominence, by proposing a wide range of techniques for data analysis and for the development of predictive models, and this was achieved in many different areas, such as predictive maintenance, consumer behaviour or defects classification. Other technologies and systems also come to characterise Industry 4.0, such as 3D printing, augmented and virtual realities, cloud computing and collaborative robots, among others. Companies faced with the potential of the technologies and applications of the so-called Industry 4.0, some of which have just emerged from research laboratories and demonstration pilots, look at their reality and try to understand the impact that this phenomenon can have on their company, and this is where the challenges and problems arise for each organization, particularly for SME. These technologies and systems have a natural and expected impact on the management structures and practices. On one hand, they require changes to be made to management practices, otherwise the value-added will be limited. On the other hand, they allow those same management processes and structures to be changed and reinvented in an innovative manner. This leads us to the concept of digital transformation.

Digital transformation may have several definitions, and the definition itself varies over time, but it is possible to translate it as being the adoption of digital technologies in all business areas of an organization, changing and reinventing its processes and its business models, to deliver value to its customers, partners and employees, among other stakeholders. As a corollary, it is something that merges people, business and digital technology, whereas Industry 4.0 has been more focused on the digital solutions and technologies.

Two more expressions have arisen in recent times, and they are digitalization and digitization. To look for the differences between all these four expressions starts to be a conceptual exercise but nonetheless interesting. If digitalization is very close to the meaning of digital transformation, being the changing and innovation of business through the adoption of digital technologies, digitization is something more primitive, in the sense that is a premise for digitalization or digital transformation. Digitization is about the transformation of analogue information into digital information, and this falls under the topics of internet of things and cyber-physical systems. It is related to the opportunity

and the need to have data that allows the performance assessment, for instance, of a process, whether it be a product, service or a manufacturing operation, or even a patient. On the technology dimension of Industry 4.0 and Digittal Transformation, a set of technologies and systems form the already popular nine pillars of Industry 4.0 (Figure 27), even if it is possible to find proposals where this number is higher.

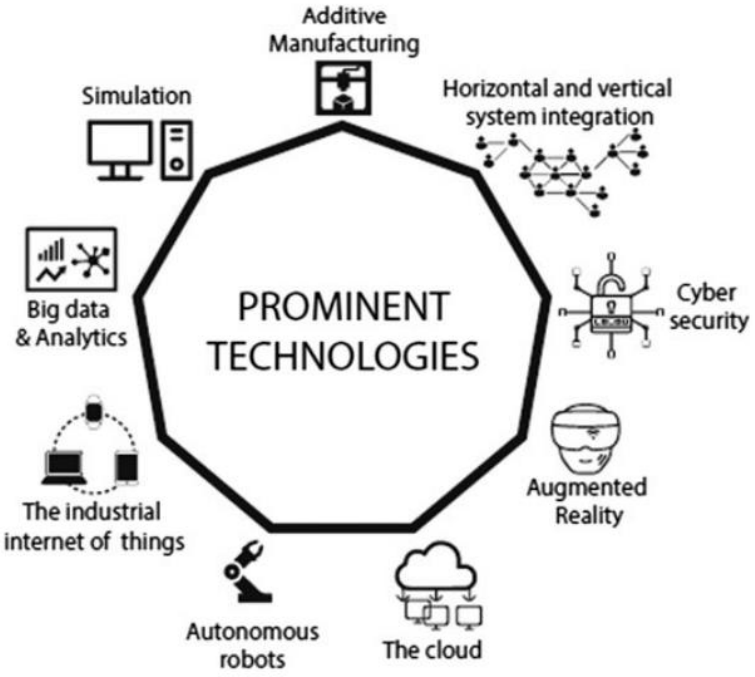


Figure 27 - Industry 4.0 Prominent Technologies

Source: Lara, Magdiel & Saucedo, Jania & Marmolejo, Jose & Salais, Tomas. (2019). Organizational Systems Convergence with the Industry 4.0 Challenge: Experiences from Latin America.

It is undeniable that all are important, but it is important to select those technologies that companies should adopt now, and those that should be adopted through a larger time horizon plan. Many companies are already well advanced in the adoption of Internet of Things technology, while other are given their first steps. The same happens with the other technologies.

Cyber-Physical Systems- Systems of collaborative computational entities connected with the surrounding physical world and its processes, making available and using simultaneously access and data processing services available on the Internet. Integration of communication and computing between virtual and physical processes. Covering all levels of production, from production equipment and physical manufacturing processes to production and logistics networks.

Cybersecurity - Technologies and services aimed at protecting industrial systems, networks, equipment, and data from unlawful intrusion.

Augmented reality - consists of integrating virtual information with the real world through the combination of virtual elements with the real environment of the equipment/machine/factory, interactivity, real-time processing, and 3D projection.

Additive manufacturing - Set of technologies that allow the printing of objects from metal or plastic placement, avoiding waste in processes such as cutting.

Big Data - Set of tools and technologies that are capable of performing the analysis and treatment of large volumes of data: generated continuously; from multiple sources, identifying in detail the existing flaws and increasing knowledge about the habits and preferences of consumers.

Intelligent Robots - A particular case of a cyber-physical system in which robots (fixed and/or mobile) operate in physical reality to automate physical processes or develop human work (in collaboration or autonomously).

Simulation - Set of technologies that allow the virtualization of processes, product design, and factory layout to achieve its optimization and improvement of models.

Cloud computing - Use of the cloud to access systems, machines, and tools in the form of a service, with companies not needing to purchase expensive products, infrastructure, and/or know-how. The use of the cloud is now widespread in data and software management.

Systems integration - Integration of data at all levels of a company between supply companies in accordance with data transfer standards. Necessary for the total automation of a supply chain, from suppliers to customers and from management to the shop floor.

3.2. ADOPTION OF DIGITAL TECHNOLOGIES

Claiming that a company has achieved an “Industry 4.0” status is ephemeral. Digital transformation is not a destination, but an ongoing process that combines people, digital technologies and processes, to deliver increased value to stakeholders (customers, employees or shareholders). As it is an ongoing process, it needs a plan or roadmap, and the related financial plan.

A first step to start a digital transformation process is to identify the level of digital maturity of the company, in order to be able to define the priorities that will shape the actions and the projects to be undertaken in the future. Several approaches for this assessment have appeared in recent years, many of them supported by self-diagnostic tools. These approaches seek to identify the performance level of a company in a set of dimensions, such as customers, suppliers, processes, leadership and management, human resources, information management, among others. This assessment is fundamentally a reflection exercise by the top management level on the company, its market, the way it interacts with it, the management of its resources, namely human resources, and the role that digital technologies currently play. The result of this reflection will point out the weaknesses and, consequently, an opportunity for improvement.

The next step is to define the actions, initiatives and projects that the company considers important. These actions will differ in their duration, risk, investment and return, digital nature, among other facets, but they are actions that should be undertaken methodically, in a project management logic, where everyone should be involved. Top management should duly monitor this plan. Although this approach seems straightforward, each company has its own concept and definition of “digital”, each company interprets its problems, challenges and opportunities differently, so it is expected to find with different levels of digital technology adoption.

There are no known sector-focused studies with broad geographical representation, so drawing an accurate picture of the current state of digitisation in the sector is difficult. It would not be wrong to assume that the major barriers the sector faces in its digital transformation are similar to those faced by companies in other sectors.

Several obstacles seem to prevent a company from taking steps towards becoming a true factory of the future. This question has been asked regularly and some answers can be found in many reports[36]. Leadership, as expected, has a prominent role in the

[36] Such as “Gartner Identifies Six Barriers to Becoming a Digital Business”, 2018, https://www.gartner.com/en/newsroom/press-releases/2018-07-25-gartner-identifies-six-barrier-to-becoming-a-digital-business; “Unlocking success in digital transformations”, 2018, https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations#; Vogelsang, Kristin & Liere-Netheler,

responsibility for the success of the transformation. Human resource management still is not fully aware of the impact from digital technologies at individual, department or organization levels. Finally, individualism. Transformation is not a solitary journey, because nowadays resources, knowledge or opportunities are not all found indoors. It is necessary to know how to make partnerships, with clients, suppliers, schools, R&D entities, equipment suppliers, among others.

3.3. TRENDS AND CHALLENGES

3.3.1. DIGITAL SUPPORT FOR THE CIRCULAR ECONOMY

The concepts of circular economy and sustainability, in their various forms and approaches, are nowadays a top priority in the policies and intentions of governments, companies and NGO. It is a global concern that has conquered its space and define consumption behaviours, product design, manufacturing and distribution strategies, among other dimensions of social and economic life.

In the linear economy, the life cycle of a product begins with the extraction of natural resources or raw materials, these are transformed in the production phases, the final product goes through distribution, which, finally, delivers it to the customer. The customer uses the product and, at the end of its use, it ends up in landfill or is generally discarded. This model assumes an infinite capacity for the extraction of natural resources and the final disposal of the products. In addition, there is the infinite capacity to generate the energy necessary to support this whole process. However, today we know that this is unsustainable. In response to this impossibility, a circular model is proposed, one in which the product at the end of its life is reused as a raw material, the product's useful life is extended, energy sources are renewable, and products and processes are environmentally friendly. These principles and actions have long been known and practised, but at levels that are still insufficient.

The shift from an economy based on the linearity of the production and consumption to a model based on circularity raises several challenges. Some of these challenges are not new, such as the continuous search for solutions and approaches to increase energy efficiency, to increase the production and consumption of renewable energy sources, and to reduce waste in the production chain. Many others challenges arise and the digital technologies and solutions are definitively part of the solution:

Kirsten & Packmohr, Sven & Hoppe, Uwe. (2019). Barriers to Digital Transformation in Manufacturing: Development of a Research Agenda. 10.24251/HICSS.2019.594.

- The European Commission has the objective to implement, in a near future, a “digital passport” for all products available in Europe. Regardless of its implementation and support technology, the digital passport is about having access to the information about the physical product, information that is useful to the, for instance, the consumer so he or she can make more responsible buying choices and contribute to the circularity of the product. This step seems logical, as similar initiatives were carried out by brands and companies. Any relevant implementation of a digital passport will require the collection of relevant volumes of data along the value-chain, data that needs to have compatible representations, quality and must be a systems that ensures trust.
- To take full advantage of recycling, a recycler must have all the information he needs about the product in order to effectively reuse it, making effective use of all materials. Therefore, there is a need to have a digital passport of the product available at this point, accessible through a smart label somewhere on the product, a label that has overcome the consumption cycle. From a mechanical or chemical perspective, it is necessary to manage the separation of the constituent materials, or de-manufacturing, processes that are not trivial and require investment in innovation and research on advanced production technology, using image processing, robotization and artificial intelligence.
- Product design should be carried out in such a way as to ensure circularity and sustainability. Therefore, the choices regarding the selection of materials and components, the manufacturing process, maintenance and repair operations, the distribution and recycling, made by a designer or engineer, will have an impact in terms of sustainability and circular economy. There is a need for better tools and information services that can support a designer making better and informed choices.
- The promotion of industrial symbiosis should be sought, that is, recognising that what is a waste for one industry is a raw material for another, it is necessary to have knowledge that allows to streamline these transactions between companies of different natures and sectors, as a contribution to circularity. Without the support of tools that provide information on this mapping and on demand and supply, it will not be possible to achieve high levels of industrial symbiosis.

Some ongoing concerns related to a sustainable industry continue to be a top priority to any company. Given the scarcity of natural resources and raw materials, as well as the need to reduce energy consumption from fossil fuels, given its costs and environmental

footprint, the industry, namely the textile and clothing sector, is forced to reduce energy consumption levels, to be more efficient in energy consumption and find ways new sources for sustainable energy. Despite the energy constraints that the world has been experiencing, new clean forms of energy production may lift these restrictions. The same goes for other resources. From a technological point of view, greater control of production processes, with more data, data analytics, better predictive or forecasting models, may contribute to fighting inefficiencies, defects in products, and thus reduce waste, both of materials and energy. Much is expected from advanced production technologies. In many ways, this array of integrated technologies, from machines to control and management platforms, not only will make possible for more efficient and effective manufacturing operations, but also must provide better digital integration with the IT and operational infrastructure. Data collected at machine level must be available with quality and in real-time to allow more complex and advanced data-based services.

3.3.2. EVER CHANGING CONSUMER HABITS

The consumer is the beginning and the end of the entire value chain cycle, and it is the justification the value-chain existence. Any deviation of the value chain from the needs and expectations of the consumer will make an impact the value chain operations, by reducing revenues and increasing costs. This focus on the final consumer is crucial for all the players along the value chain, and only with a highly integrated value-chain both at product and information flow will be possible to respond with efficiency and effectiveness to changes in consumer habits.

One of the trends that has been progressively growing importance is product personalization, i.e. the possibility of adapting the product to the tastes and needs of each consumer, even allowing the consumer to design the product they want. As an opportunity, personalization demands the sector to overcome current obstacles in order to satisfy consumers in their demand for a personalised product, a product that adapts to their needs and expectations and that has elements of their own, if not a product of their complete authorship. This customisation can also take place at a local and regional level, or community level. This happens, for instance, when the portfolio of products for certain brands changes from city to another. This personalisation trend requires a huge investment in "consumer experience" combined with digital technologies, as the consumer is increasingly digital and the business model that offers this kind of service can only be viable when digitally supported.

There are several challenges that this approach raises: what is the range of options that the consumer can personalise; how to build a viable technical product specification with

the data collected from the consumer; how to design and exploit an optimised, flexible and sustainable business model, with production capable of small, or even unitary, batch sizes, or; what role for additive manufacturing and 3Dprinting in the textile and clothing sector?

This path towards full-personalization puts the consumer at the centre of the whole chain and pushes the whole chain to be closer to the consumer, both in terms of geography and interaction channels, to be able to react promptly and, above all, to anticipate their behaviour. This is the only way to provide a more valuable consumer experience, something that is worth as much or more than the intrinsic characteristics of the product. Currently, the market already has some business cases that already offer some degree of customisation. Choosing the colour, a certain type of finish or cut, or the made-to-measure, is already possible, and the trend is increasing.

Another trend addressed here is online shopping, a growing trend that brands have recognised and acted upon, with varying degrees of innovation and success. What is certain today is that the division between customers who shop in brick and mortar retail shops and those who shop on digital platforms is getting smaller, even vanished. The focus is now on the consumer journey and recognising that the customer is one and will interact with the brand at different times and through different channels, whether these are the shop or the sales portal. The journey may start at night, on the web, go through a visit to the shop and the purchase may take place on the mobile phone, in the middle of the afternoon. This demands an omnichannel strategy focused on the consumer. Progressively, brands will seek to emulate the kind and level of interaction achieved on online channels in physical stores, and seek to integrate all channels into a single strategy.

These two trends combined will make an impact not only at the front office, but it will propagate through the entire supply channel, including the industry. If the time of two collections per year is long gone, we will move quickly towards to offer the customer what he wants. This translates into increasingly fragmented lots and this requires flexibility on the industry's side.

3.3.3. INTEGRATED SUPPLY-CHAIN

The new European industry will have to adopt the principles of sustainability and circular economy, while being an industry anchored in digital technology and systems. The challenge today is to provide companies with greater flexibility in their operations to respond faster, to cope with smaller and smaller orders and for diversified products, and

to deal with unexpected events that cause sudden changes in the market, such as the example of the COVID pandemic. Today, this level of desired flexibility can only be achieved by applying digital technologies to business processes, optimising and even reinventing them.

However, the challenge also demands for a greater integration of processes between companies in the value chain. There is a limit to the gains that can be obtained from the optimisation of a company's internal processes, therefore, additional gains will have to come from other sources, and these are in the relationship with its customers and suppliers. Companies operate in chains and are integrated into global business processes. Therefore, each company is a link in a chain through which physical artefacts, such as raw materials, components or finished products, and information go through. It is precisely at the information level that integration has not yet happened. With the exception of developments around electronic document sharing (the so-called EDI, "Electronic Data Interchange"), digital integration between the members of a supply chain is low. Paper is still used as a transmission medium and when the information has a digital support, information exchanges are mostly mediated by human agents. This scenario invariably leads to increased costs for companies due to delays, errors and the absence of reliable information for decision-making.

Even supplier portals are still far from the ideal solution, as they only solve the problem of the customer, transferring the burden of data acquisition and processing to the suppliers, with these needing to interact with different portal for different customers, dealing with different volumes of data, and different data structures.

To achieve a full integrated supply-chain, two challenges must be addressed: universal (wide adopted) information models and reference models for data exchange. A wide adopted information model will allows representing with the same amount of data the everyday objects of the fashion industry, like a coat, a fabric a yarn or a machine. Without such a consensus, the exchange of data between companies is and enormous and costly exercise.

A reference model for data exchange will specify the messages that one company can exchange with another, defining the requirements for the content of the message, for the context in which the exchange occurs, for the sender and for the receiver, etc. The existence of a standardized reference model as this is imperative to achieve a level of automation of the data exchange between companies.

As the consumer’s journey gets more dynamic and personalized, higher levels of supply

chain integration are needed. Currently, it is possible to work from a blank sheet of paper to the placement of the product in a sales portal only in digital support. This means that it is possible to test products and concepts with the consumer without having to actually produce them. Soon it will be normal to accept orders for clothing that has not yet been produced. This dynamic will certainly grow around personalization and the enrichment of the consumer experience. Industrially, this will translate into the production of small series continuously, with a minimum production and delivery time and that can no longer be produced globally. It is in the middle of the convergence of these factors that the digital integration of the value chain is important, because this is the only way to achieve the necessary flexibility to respond positively to these challenges.

3.3.4. DIGITAL PRODUCT AND PROCESS

The digitalization of the textile product means the ability to digitally and fully represent the physical textile product with the appropriate accuracy and necessary information. This ability is part of what is considered to be the management of a product's life cycle, that is, the actions required to manage and operationalise the life of a product, from its conception, through design, industrialisation, distribution, sale, support and, finally, the operations associated with the end of the product's life. All these practices together make up the "product lifecycle management" (PLM). Several PLM software tools and products exist for the textile sector and PLM functionalities are present in many other management software and ERP products.

The digital product, a central element of a PLM approach in an Industry 4.0 scenario, consists in having all product information in digital format, accessible to the different actors and within the right contexts. This information comprises, among others, the product's material characteristics, dimensions, manufacturing process, quality criteria, technical drawings, among others. Having a complete digital tech pack will support adequately the set of operations that are relevant in terms of a better performance of the operations and will provide a strong base for new and innovative business models. Major positive impacts that can be expected from this digital twin approach:

- The product design and engineering process can be carried out without the production of samples, something that will decrease significantly the material and resources consumptions;
- It allows the simulation of both the product and its production, thus identifying possible design flaws;

- Virtual proof of the product, with an impact on the business model, by allowing the end customer to have a realistic perception of the final product, without the need to touch it or, in the fashion case, to wear it;
- In terms of market shift paradigm, it will allow the product to only have a physical instance when it is needed, powering a business model that produces what is already sold, and fighting this way the big problem of overproduction and deadstock;
- It allows a made-to-measure business-model in a viable way.

To a large extent, current software products on the market for product design and development allow the construction of a garment already in 3D and with sophisticated simulation capabilities.

3.3.5. ROBOTIZATION

In recent decades, automation has contributed with important gains in productivity, by freeing material handling operations from the hands of human operators, replacing them with machines with high precision and speed. The human operator, in many cases, became necessary only to feed these machines with components and raw material and, on the other side, to remove the parts after they have been processed.

Robots have been known for decades, but in Industry 4.0, robots take on a different dimension. They are connected, act autonomously, can see and feel, and can work collaboratively side by side with a human. There are numerous examples of the use of this new generation of robots in an industrial context. However, the textile sector presents several challenges that are not yet overcome, with the result that there are no mature solutions on the market and the sector is dependent on a high volume of human labour. The main problem lies on the flexible nature of the textile, which makes its manipulation by robots extremely difficult. The fabric loses its geometry and orientation when manipulated by grippers, which makes the robot's job difficult. Although in many textile processes the application of robots is already a reality, the sewing operation, a crucial operation in clothing production, is still very dependent on human effort and it is unlikely that the human operator will be replaced any time soon. Moreover, the fragile nature of fabrics limits the technology used by grippers to handle them, due to the risk of causing damage.

This scenario is an obstacle to the reindustrialisation of Europe as far as the fashion sector is concerned, because if the need for human intervention in the process remains

high, these operations will hardly be able to be carried out in Europe on a larger scale than at present, remaining in geographies where the salary wages are, in average, lower. This is an issue in which both sectors, textile and clothing and advanced manufacturing technologies, must invest in innovation in order to seek reliable and accessible solutions in the near future. There are projects that are showing some advances in this area, but still without ready-made solutions.

3.3.6. SMART MACHINES AND SERVITIZATION

Servitization can be roughly translated as the ability of a manufacturer to have revenues through the provisions of services. Services like maintenance or repair are usual revenues sources, alongside the primary revenue source that is often the selling of the equipment.

However, with the advent of the digital technologies and solutions of Industry 4.0, such as IoT, sensors, embedded computing and others, machines inherit the capacity collect data from sensors that measure its operational performance, are able to perform complex data processing are able to interact with external sources through communications protocols. These capabilities transform them into smart machines or smart products, capabilities that allow for new services or new business models. Some examples are predictive maintenance, pay-per-use models, remote assistance or self-configuration.

If this is already a reality in production technologies, within the textile and fashion business there are no sound examples, although the number of promising projects, ideas and prototypes that combine textiles with electronic components and processing ability. Several problems exist that need to be solved in order to power a significant market for smart textiles. Examples such as the difficulties in providing service support for maintenance and repair of such products, where simple operations like washing can pose serious questions. Also, the lack of industrial capacity and even knowledge to produce smart textile product at scale.

4. GLOBAL VALUE CHAINS

4.1. WHAT ARE GLOBAL VALUE CHAINS?

A value chain is the set of all activities that provide or receive value from designing, making, distributing, retailing and consuming a product, or providing the service that a product render. In this sense, value chains cover all stages in a product's life, from supply of raw materials, through the disposal after use, encompassing the activities linked to value creation such as regulations or investments.

Thus, for the global value chains, we understand that the different stages of the production process are located across different countries due to globalization.

When referring to the textile sector, the value chain starts with the sourcing of raw fiber production (right after there has been a process of research and design). These fibers can be sourced either from natural agricultural materials, or through an industrial manufacturing process. Later, these raw materials are going to be transformed into the components (yarn, fabrics, etc…) that will eventually be manufactured, through a process of transformation, into the final products (garments, technical textiles, technical fibres, etc…). The final stage involves the distribution the retailing (marketing), and the final usage of the product.

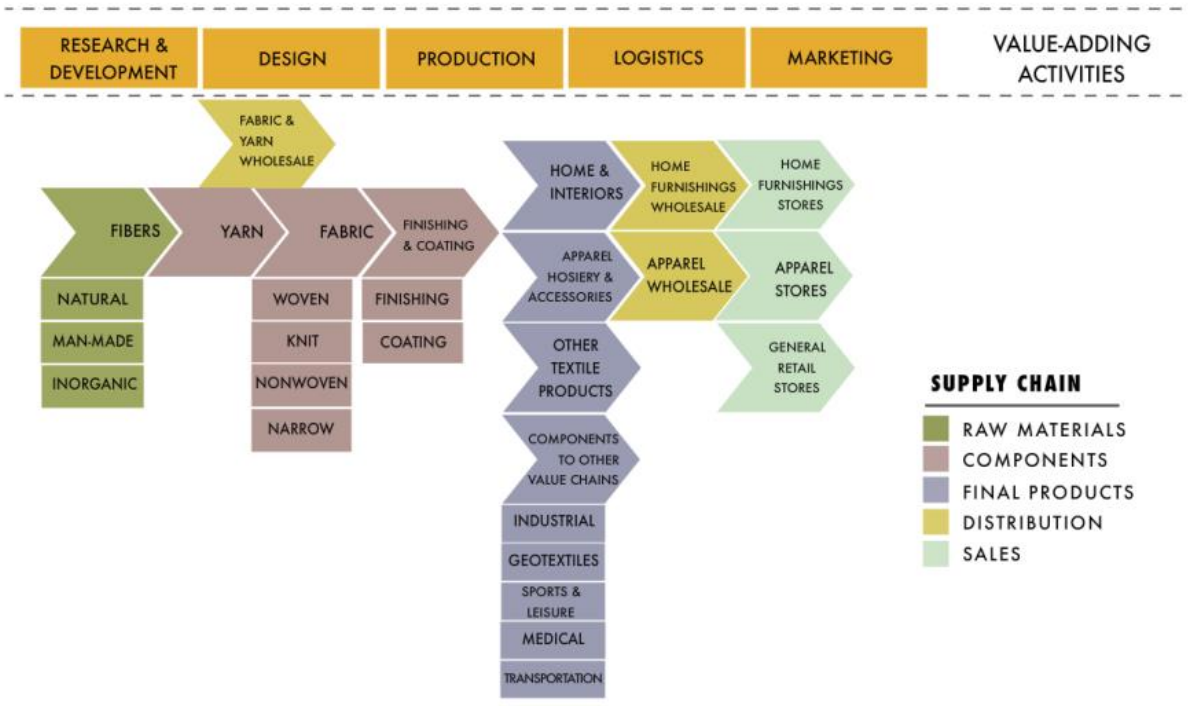


Figure 28 - Example of the textile value chain structure. Source: Source: UN Environment Programme

Currently, less than 1% of the produced textiles are recycled back into clothing, and another 12% is downcycled or cascaded, which means that the resulting materials obtained are of lower quality and functionality than the original material. Most of the textile products end up their life cycle by being incinerated or processed in a sanitary landfill.

The whole textile value chain exposes a very clear linear route, which can be seen as a sign of multiple shortages such as: Waste of resources, especially at the end-of-life cycle; Lost of productivity due to the lack of interaction with complementary supporting activities, namely those that can reduce the environmental impact; A more expensive value chain due to the lack of design based thinking approaches and globalization of the raw materials supply chain.

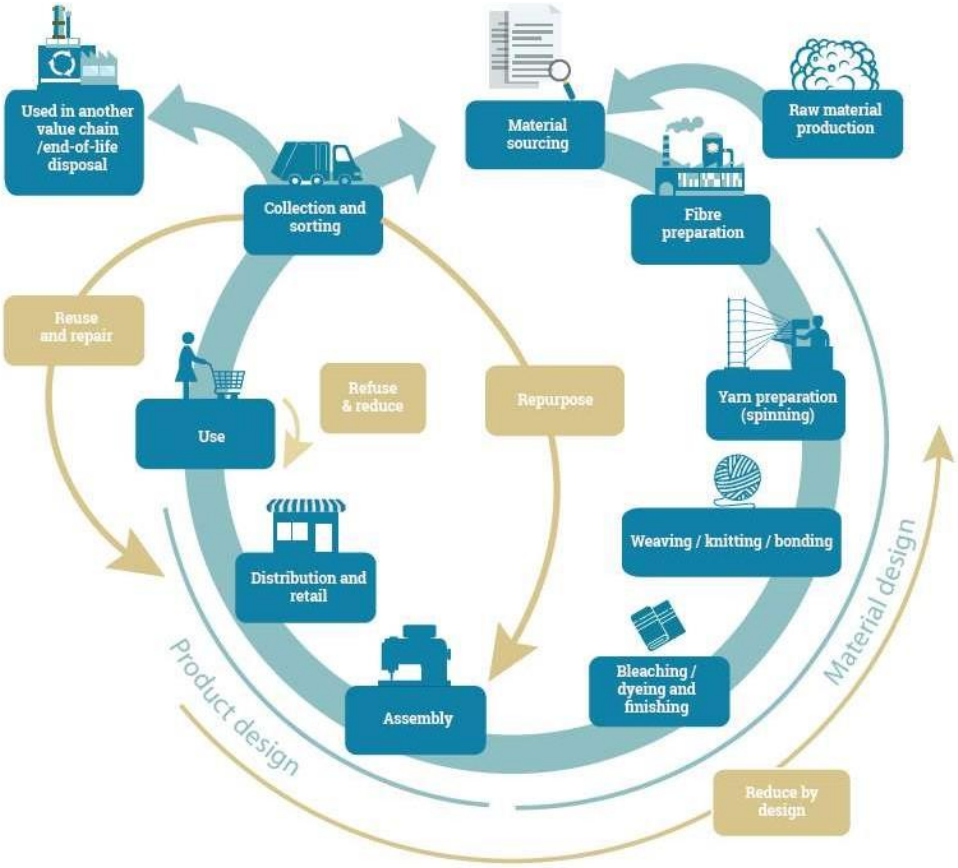


Figure 29 - Representation of activities taking place in a Circular Economy. Source: UN Environment Programme

The aim of circular value chains is to curve this “take-make-dispose” tendency of linear value chains, and create a system where materials are not lost after use but remain in the economy, circulating as long as possible at the highest value.

Hotspots along the textile global value chains

We consider hotspots those stages in the life cycle of a product or service that accounts for a significant part of its environmental, social, and economic impacts. By analyzing the hotspots, we are looking for strategies that would allow us to tackle the problems associated to the production process, focusing on priority needs in order to achieve the maximum efficiency and impact reduction of the value chain.

Below, it is possible to find a list of the most relevant hotspots located along the textile value chain:

Hotspots	Main problems
Fiber Production	• High use of **fossil fuels** to produce synthetic fibres (climate, human health, ecosystem quality impact) • High use of **agrichemicals**, land, and water to produce natural fibres, especially cotton (biodiversity and ecosystem quality impact); • **Unsafe working conditions** and **fragility of the legal system** (social risks and human health impact).
Yarn and Fabric Production	• Even though the Yarn and fabric Production contributes to the damage dealt to the ecosystem, along with other social risks, it is considered to **not be enough to consider hotspots** during this stage.
Textile Production	• High use of **fossil fuels** for heat and electricity generation; • Use of **hazardous chemicals**; • Release of **microfibers** (ecosystem and human health impact); • Unsafe working conditions and fragility of the legal system.
Consumer use Phase	• High use of **electricity** in the care of textiles over their lifetime (climate, human health, and ecosystem impact); • High use of **water to clean clothing and releasing of microfibers** during the washing over their lifetime.
End-of-Life	• **Low rates of recovery** of textiles at the end - of - life cycle (high material value loss, incrementing the impact of all other stages).

Roles in the Global Value Chain

As the global value chain is the set of all actors and stakeholders that provide or receive value from any part of the textile product process (from its production to its use), it is important to understand, in order to find market opportunities, in what role do these actors play in each stage of the value chain.

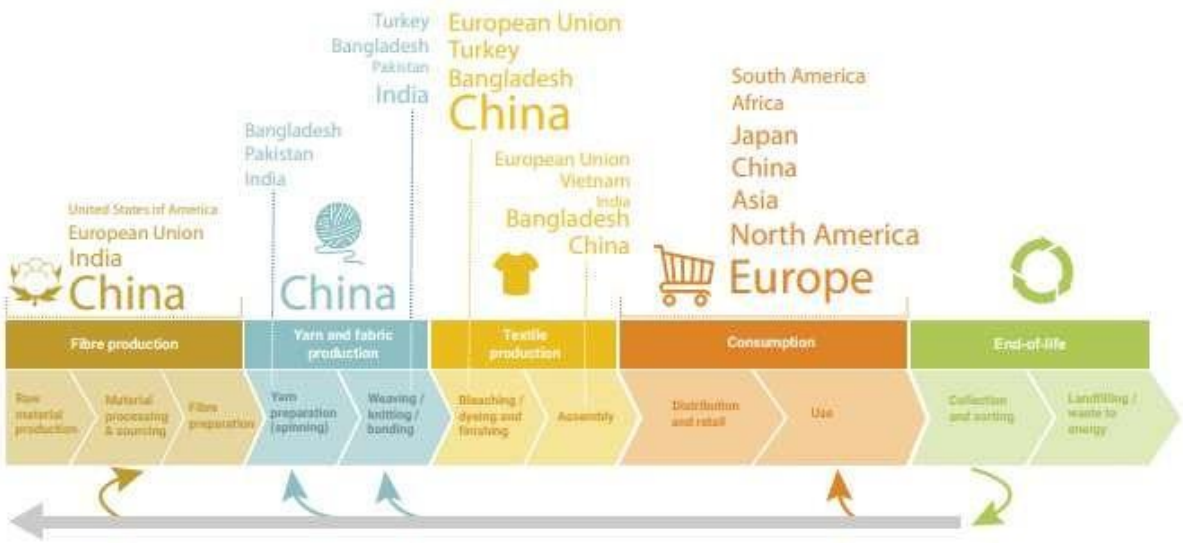


Figure 30 - Geographical breakdown of global apparel production and consumption
Source: UN Environment Program

The production stages of the apparel textile value chain are leaded by Asian countries such as China, India, or Bangladesh. On the other hand, when it comes to consumption, Europe and North America are the major players. This dichotomy can be explained by the fact that the production process of the apparel textile industry has headed towards a dynamic based on **low-cost production**, scenario of which **developing/transition economies** such as the ones mentioned are leaders.

This scenario does not give many chances to Europe, at least when it comes to compete in the apparel textile sector, so it is forced to take the lead and focus on other high added value markets like the technical textiles markets. To do so, it is required an investment strategy focused on developing new technologies, promote innovation, and improve productivity of the global value chain. An example of this would be the development of new production processes involving high-tech textiles, such as the “smart textiles”.

Textiles of the Future – Smart Textiles

A Smart textile is a functional textile material, which interacts actively with its environment and responds or adapts to changes in the environment. These textiles react to external stimuli (light, temperature, humidity, pressure, etc.), and have the ability to communicate with other devices, to conduct energy, to transform into other materials, and to protect the wearer from environmental hazards.

Smart textiles bring functions to end-products and are used in sectors with high added value such as the health and medical industry; automotive & aeronautics; personal protective equipment; sports; construction; and interior design, among many others. The worldwide market for smart textiles was expected to expand a 14% at a compound annual growth rate between 2014 and 2020, and also to rise its market valuation from US$ 1,5 billion in 2013, to US$ 3,8 billion by 2020.

However, even though these textiles have a promising future, they are not exempt of challenges. Integrating electronic materials into the core yarn of smart textiles is technically very complicated and it sill requires research to be done. Many companies may not have the infrastructure to manufacture these textiles and they require to re-program their production processes. The high production costs are probably an entry barrier for many small-medium sized companies.

The scope of smart textiles addressed here refers to textile-base products with embedded electronic components, whether these components are conductive yarns or sensors. This kind of products are important and represents an opportunity for the textile sector to evolve and enter the domain of smart-products, a domain already familiar for domestic appliances manufacturers and others.

Examples of textile smarty products exists, many still in the form of a prototype or advanced prototype. For example, a firefighter's uniform equipped with a heartbeat sensor that can send this data remotely, or a worker wearing a suit that can detect bad postures issuing a warning signal. The aspect that is important in these examples is the value-added service that can complement the product, that in many cases can the basis of a new business model.

This is the opportunity for the textile and clothing sector expand itself into other business areas, and to attract people with different skills and competencies, such as electronics and programming.

Innovative trends in the global value chain, and market opportunities

International production, trade and investments are increasingly organized within the global value chains. Globalization motivates companies to restructure their operations, by locating the various stages across different sites, to achieve a resources and production's optimization.

Promoting the improvement of the textile global value chains and tackling the hotspots inherently present in all along its stages suppose an increase of productivity and efficiency, from which not only the advanced technical textiles industry would benefit, but also the whole planet and ecosystem.

According to a report initiated by the European Commission's Directorate General for Internal Market, industry, Entrepreneurship and SMEs, in the Executive Agency for Small and Medium- sized Enterprises in the framework of the "Advanced technologies for Industry" (November 2020), multiple trends in the generation and uptake of advanced technologies and market opportunities have been analyzed, some of which are going to expose in this report.

As we know, textile industry has suffered from an accelerated transformation process thanks to the implementation of new technologies and innovation in the production processes, including redefinition of costs and introduction to global market opportunities.

However, these market opportunities bring with them new challenges that need to be overcome in order to being able to build a successful global value chain.

Most of these challenges are related, driven by an increasingly customer's demand (both individuals and industrial players) for **eco-friendly textiles.** There are crucial factors driving new research and innovation in the textile industry correlated to the environment:

- A growing demand for sustainable and eco-friendly products, materials, and businesses practices;
- More interest in developing resource-efficient processes and less undesired outputs;
- A crucial need in investing in new technologies, processes, and business practices to become more competitive in comparison with other global actors involved in the global value chain;
- A need to fulfill the customer's desire for a more sustainable image of the companies.

Technological trends

The uptake of digital, environmental, and recycling technologies will become critical for the survival and renewal of the technical textile industry. In particular, **AI technologies, 3D design,** and **Virtual Reality** will pivot the transformation to a more innovative and productive industry, helping to improve critical stages of the value chain such as the supply chains, and the ability to connect with customers all over the world without investing much logistic resources.

Keeping a track on the patented activities is a good mechanism to understand where the technical textile sector is heading its innovative transformation.

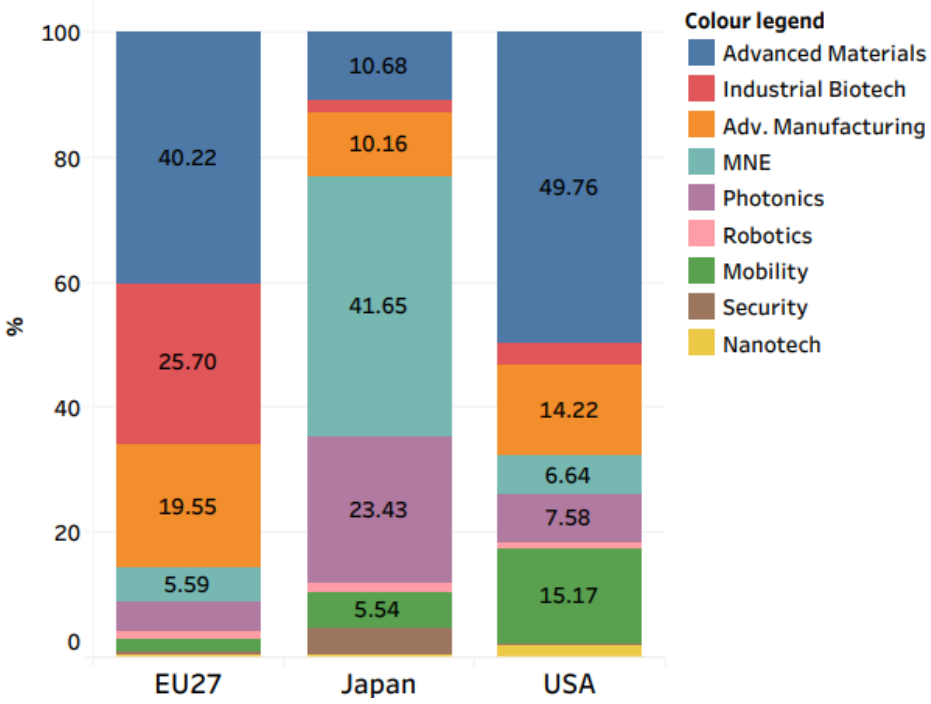


Figure 31 - International Comparison of Technology Patents by Textile firms in 2010-2017. Source: ATI, 2019

Before Covid times, Advanced Materials have represented a technological field where European textile firms have patented the most, followed by the Biotechnological industry. Nowadays these technologies not only have kept being an important trend of technological investment for textile companies, but they have been steadily growing. New materials with an anti-bacterial and antiviral function are expected to be in higher demand because of the Covid-19 pandemic. In particular, the medical textile market has been the big beneficiary of the Advanced Materials technology investment.

The same way, Digitalization has also been an important trend of technological

investment during the pandemic. Companies have seen themselves in the critical urge to enhance their digital communications due to the lack of movement provoked by the circumstances. These technologies are used mainly to enhance the trading aspect of the value chain (big data for managing information), optimize algorithms and their applications for a better consumer behavior tracking, and improving their networks.

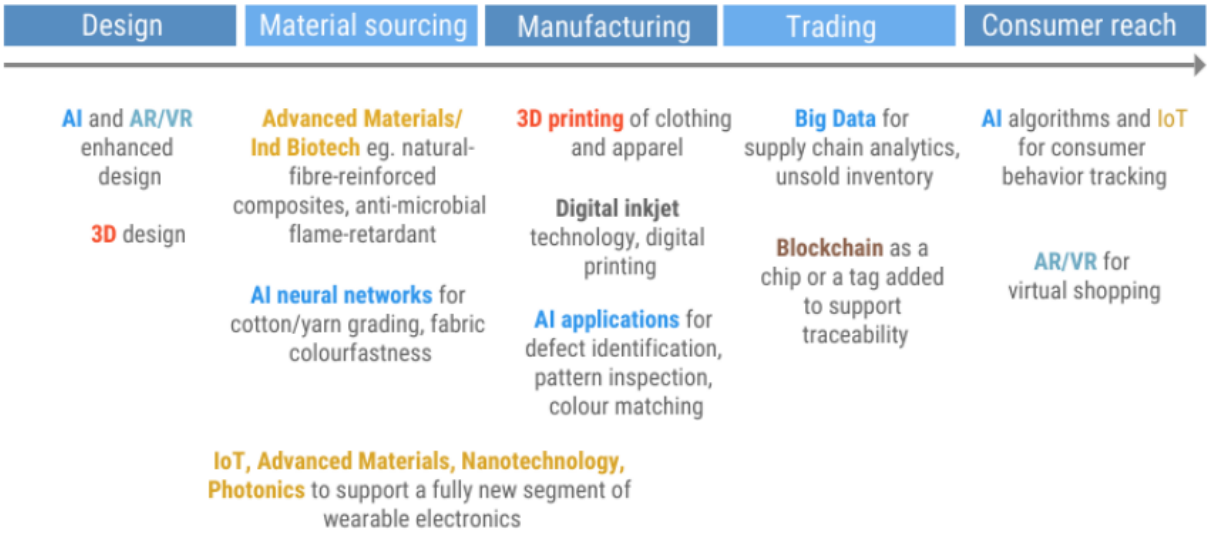


Figure 32 - International Comparison of Technology Patents by Textile firms in 2010-2017. Source: ATI, 2019

The contribution of Artificial Intelligence (AI) to the field of textile industry is relatively new, but it is increasingly starting to have an important role. The use of AI in textile processing is limited to few applications, usually in machine vision to detect malfunctions and anomalies in the textiles. However, the new industry is developing this technology to further use in more applications, such as:

- Machine learning to filter and identify useful data to help businesses improve efficiency and maintenance;
- Machine learning to optimise inventory and supply chain management;
- AI-based design of new fibres and materials;
- AI algorithms to track consumer behaviour.

Augmented reality and virtual reality is a very new concept, and its technology could even being considered to be still in prototype phase, but in the future it will be considered of high value, specially in the retail phase and customer engagement (improving customers experience). Focusing on the customer experience and branding could help reduce the marketing efforts by improving its quality and reducing costs, and it could also

be helpful in reducing the climate impact by having a more digital approach, instead of physical. Moreover, VR also has its technical applications, like using the technology to improve the textile production or perfectioning the machine maintenance.

3D printing has been largely used in engineering and manufacturing thanks to its ability to reproduce with precision complex objects from a large variety of materials. Thus, there is no wonder the textile industry, especially the technical textile manufacturing industry, has this technology on sight to apply it to its processes. 3D is providing the textile industry the possibility to experiment with innovative materials and structures that could not be done before.

Opportunity in reshaping textile industry value chains

The Covid-19 pandemic has changed the world and so the textile industry too. These new trends are forcing companies to rebuild their strategy and rethink their value chains. This supposes a change in the **partnership deals**, more investment in **new technologies**, a complete jump into the **digitalization** of their business, and other actions in order to gain advantages that are more competitive.

Sustainability and ethical textiles have become a key point in the transformation of the textile industry. Customers, both individuals and industrials, have become more concerned and ask for more **ecologically produced textiles**. In order to achieve the demanded status, textile companies will need to focus on energy efficiency, emission controls, and an overall quality improvement of the production process. As the market also demands lower prices, competition with Asian countries – which generally do not apply the same ecological standards- will be tough. However, it is expected to compensate the costs by an increase in the **productivity**, and the **add value task force**, because of a technological investment strategy.

As mentioned before, AI and **big data** will play a crucial role in renewing the industrial textile as customers look for more personalization and convenience. Including **Internet of things** in the digitalization transformation will also be imperative, as managing big data and large inventories are becoming more difficult to deal with.

4.2. GLOBAL VALUE CHAINS UNDER PRESSURE

The COVID-19 crisis has created disruptions across Europe's economy and society. Those disruptions directly threatened industries in Europe. The need to secure business continuity and competitiveness during growing instability has pushed resilience into the spotlight and made it a priority for EU policy making. The commission and its member-states have put large efforts into recovery plans that should support investments and reforms to boost their economies.

In this section, while presenting a general framework for a more resilient Europe and the financial instruments created by the EU, we will focus on the impact for the textile, advanced manufacturing industry, and provide examples of measures that could support industries to address these challenges.

Increase Europe resilience: 4 Interrelated Dimensions

As defined by the European Commission in its strategic foresight report, charting the course towards a more resilient Europe:

"resilience is the ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair, and democratic manner. Resilience is necessary in all policy areas to undergo the green and digital transitions, while maintaining the EU's core purpose and integrity in a dynamic and at times turbulent environment."

The EC outlines four interrelated dimensions regarding Europe resilience that should influence policies: **social and economic, geopolitical, green, and digital.**

1. The social and economic dimension

In this dimension, resilience entails the ability to tackle economic shocks and achieve long-term structural change in a fair and inclusive way[37]. The challenge is to build the social and economic conditions for a recovery, aiming for transitions while promoting social and regional cohesion, and supporting the most vulnerable in society.

Private and public investments, in line with the EU's policy goals of inclusiveness, digitalisation, decarbonisation and sustainability, can be a key to addressing these aspects. The 2021-2027 multiannual financial framework and Next Generation EU will

[37] Strategic foresight report 2020, EU : https://ec.europa.eu/info/sites/default/files/strategic_foresight_report_2020_1_0.pdf

be used to foster investment, innovation and economic convergence between Member States and ensure the good functioning of the single market. The Recovery and Resilience Facility (RRF) - presented in the following point - will foster social and economic resilience by supporting investment, including targeted measures for small and medium entreprises (SMEs) to help them address their present needs and those associated with long-term transitions.

2. The geopolitical dimension

Geopolitical resilience refers to Europe's capacity to strengthen its 'open strategic autonomy'[38] and global leadership role within a highly interdependent world of competing powers.

Boosting Europe's open strategic autonomy is a priority for Europe as stated in the updated industrial strategy presented last May 2021 by the EC.

The combination of global business models with increased consideration for localization of production, consumption, and taxation will offer renewed opportunities for the EU to position itself as a frontrunner at world level. Some challenges need to be addressed such as the diversification and consolidation of global supply chains in critical sectors and the strategic approach to raw materials. This requires building diversified value chains, decreasing dependence, raising circularity, supporting innovation for alternatives and ensuring a greener and socially responsible level playing field in the single market and beyond[39].

Industrial alliances supported by the EC in the framework of the recovery plan can be an interesting tool to progress as they bring together investors, public institutions and industrial partners to help industry develop strategic technologies.

3. The green dimension

Green resilience is about reaching climate neutrality by 2050, while mitigating and adapting to climate change, reducing pollution and restoring the capacity of ecological systems. The green resilience entails eliminating dependency on fossil fuels, reducing

[38] Open Strategic Autonomy enables the EU to be stronger – both economically and geopolitically - by being: i) Open to trade and investment for the EU economy to recover from the crisis and remain competitive and connected to the world, ii) Sustainable and responsible to lead internationally to shape a greener and fairer world, reinforcing existing alliances and engaging with a range of partners, iii) Assertive against unfair and coercive practices and ready to enforce its rights, while always favouring international

[39] Cooperation to solve global problems. (EC, 2020)

impact on natural resources, preserving biodiversity, developing a clean and circular economy, achieving a toxic-free environment, changing lifestyles, production and consumption patterns, climate proofing infrastructure, creating new opportunities for healthy living, green business and jobs, actively pursuing ecosystem restoration, as well as saving the seas and oceans[40].

This dimension goes hand in hand with the general objectives of the multi-annual strategy of the EC – the European Green Deal - that targets a climate-neutral society by 2050.

The industry is identified in the transformative agenda of the Green Deal. Using fewer primary resources in a circular economy will benefit the environment and the economy: it requires putting in place resource efficiency measures and sustainable use of renewable resources, and fostering the development of circular business models.

The fashion and textiles industry plays a vital role in helping societies to shift from an extractive, wasteful and risk-multiplying value chain to a circular business ecosystem that can adapt resiliently to today's realities.

4. The digital dimension

Digital resilience is about ensuring that the way we live, work, learn, interact, and think in this digital age preserves and enhances human dignity, freedom, equality, security, democracy, and other European fundamental rights and values[41].

Hyperconnectivity and digital technologies deployment continues to accelerate.

Digital technologies, advanced production and manufacturing technologies can contribute to greening the economy. They can optimise the operation of utilities, mobility and transport, products, industrial processes and buildings and other assets, leading to energy savings, pollution reduction and increased resource efficiency by enabling the transition to a circular economy. They can also improve environmental and risk management through early warning systems[42].

[40] Strategic foresight report 2020, EU

[41] https://ec.europa.eu/growth/industry/policy_en

[42] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_1884

A new industrial policy for Europe

The March 2020 Communication presenting the new European Industrial strategy lays the foundations for an industrial policy that supports the twin transitions. This makes EU industry more competitive and enhance Europe's strategic autonomy. The strategy aims at facilitating:

- A globally competitive and world-leading industry;
- An industry that paves the way to climate-neutrality;
- An industry shaping Europe's digital future;
- A more circular economy.

The European industrial transformation is based on a set of fundamentals areas as illustrated in the figure below. Those fundamental areas renew or expand on existing approaches in innovation, investment, standards or reflect the need for new ways of working to strengthen industry transitions.

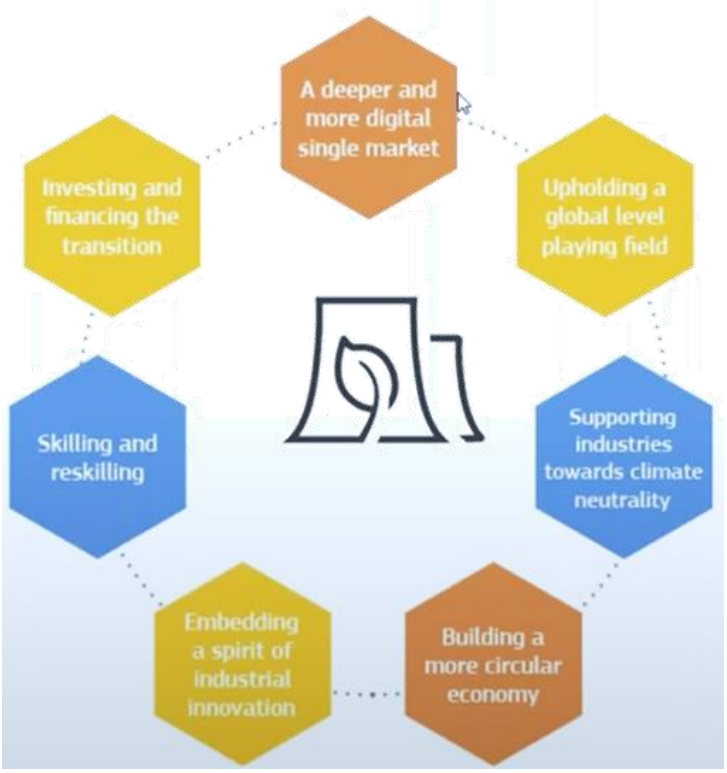


Figure 33 - The 7 fundamental areas of the 2020 European Industrial Strategy. Source: European Comission 2020

In 2021, the European Commission published updates on its industrial strategy. The objective is to guarantee that European industrial ambition takes in consideration the new circumstances generated by the COVID-19 crisis, while ensuring European industry

can lead the way in transitioning to a green, digital and resilient economy[43].

The crisis has exposed the interdependence of global value chains and shown the importance of a globally integrated and well-functioning single market. Specific issues were faced such as the closing of borders that affected and restricted the free movement of goods and services, global supply chain interruptions that impacted the availability of essential products, or even some disruptions in demand in the countries.

If the crisis revealed the resilience and adaptability of some of the EU industry, it confirmed the need for more speed in the transition towards a cleaner, more digital and more resilient economic and industrial model.

The updated strategy maintains the priorities set out in the March 2020 communication, while addressing the three main learnings:

- The need to strengthen the resilience of the Single Market;
- The need to better understand EU dependencies in key strategic areas;
- The need to accelerate the green and digital transitions.

Measures included in the recent update aim at reinforcing the resilience of the industry. Improving conditions for business finance and SMEs in particular, are included to support and accelerate their engagement in the twin transitions.

Strengthening Single Market resilience

The single market is the most important asset for the EU and is a global facilitator for companies. In order to strengthen the single market, the EU will create a Single Market Emergency Instrument to ensure the availability and free movement of goods and services. This instrument should guarantee more transparency and help address critical product shortages by speeding up product availability and reinforcing public procurement cooperation.

The Commission will put in place other measures to assess the main barriers and address restrictions to the single market covering a number of areas such as the service sector, business services, and single market surveillance. Other targeted measures for small and medium-sized enterprises are planned, including significant investment to support SMEs as part of InvestEU and REACT EU initiatives.

[43] https://ec.europa.eu/info/sites/default/files/swd-strategic-dependencies- capacities_en.pdf

Figure 34 – Key Actions: Deepening Europe Single Market – measures summary
Source: European Commission. DG GROW, 2021

Addressing EU strategic dependencies

If openness to trade and investment is a strength and source of growth and resilience for the EU, disruptions in global supply chains can lead to shortages of certain critical products in Europe as experienced during the COVID19. Hence, identifying and addressing the EU's strategic dependencies is essential.

Out of 5,200 products imported in the EU, an initial analysis conducted by the EU identifies 137 products in sensitive ecosystems for which the EU is highly dependent – mainly in the energy intensive industries (such as raw materials) and health ecosystems (such as pharmaceutical ingredients) as well as concerning other products relevant to support the green and digital transformations. 34 products are potentially more vulnerable given their possibly low potential for further diversification and substitution with EU production. Challenges and dependencies in the area of advanced technologies are also identified[44].

[44] 6 in-depth reviews were carried out: batteries, active pharmaceutical ingredients, hydrogen, semiconductors and cloud and edge technologies

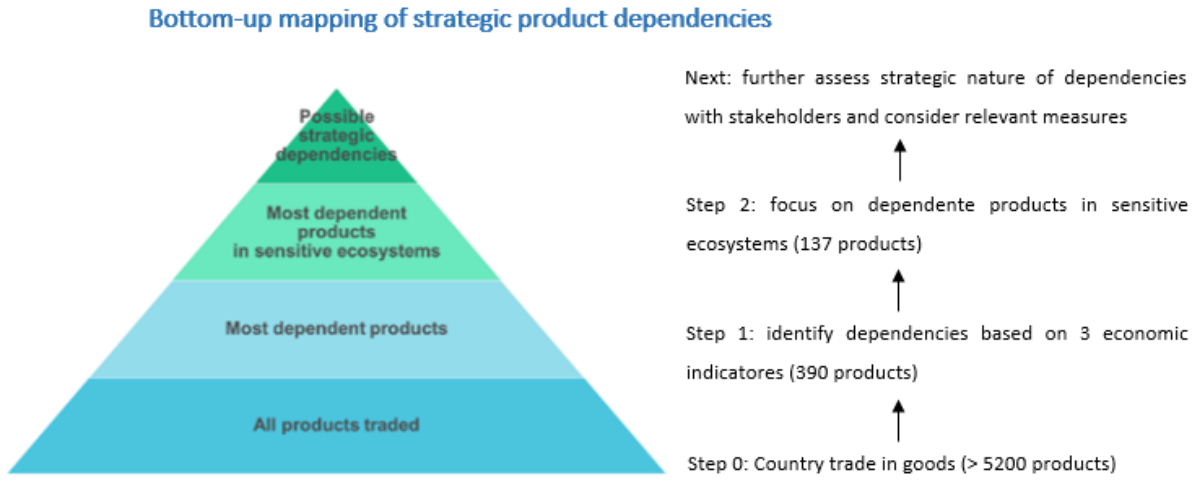


Figure 35 - Bottom-up mapping of strategic product dependencies. Source: European Commission. DG GROW, 2021

Therefore, in-depth reviews on raw materials were conducted on specific areas[45] to provide further insights on the origin of strategic dependencies and their impact. A second stage of review in key areas including products, services or technologies crucial to the twin transitions is planned. The commission will develop a monitoring system to address these strategic dependencies.

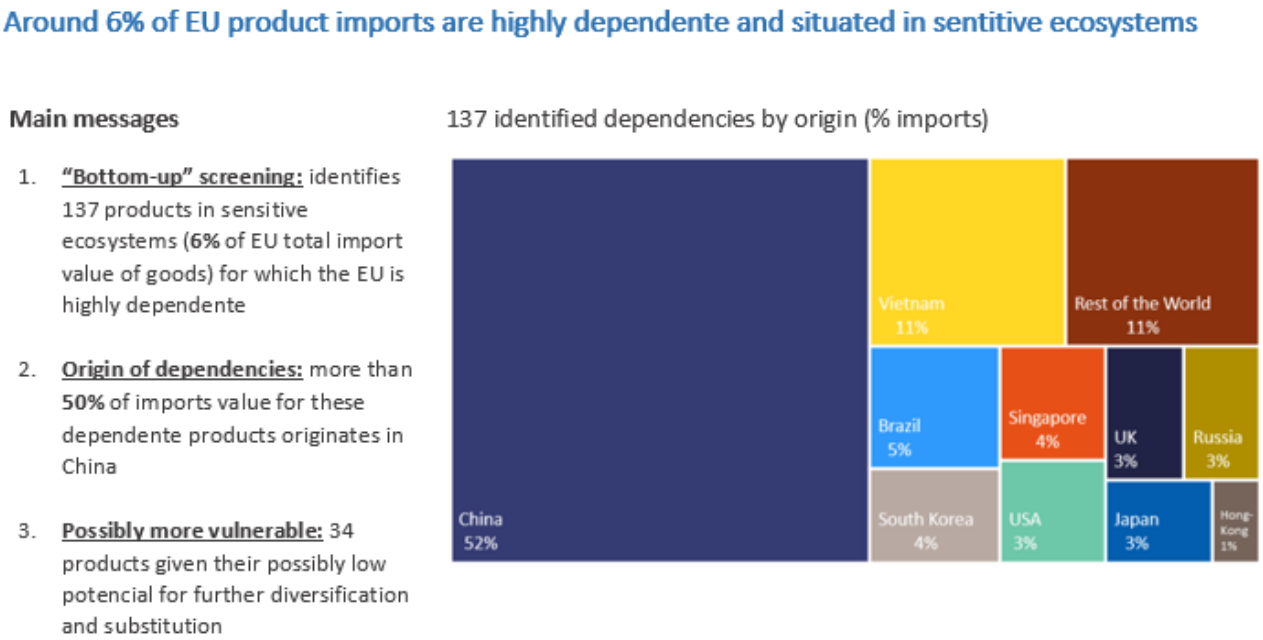


Figure 36 - EU Product imports dependencies. Source: European Commission. DG GROW, 2021

[45] https://ec.europa.eu/info/sites/default/files/swd-strategic-dependencies- capacities_en.pdf

The EU will also support new industrial alliances in strategic areas. Those partnerships could represent important tools to accelerate activities that would not develop otherwise, with potential for innovation and growth.

Accelerating the Twin Transitions to a Green and Digital Economy

The 2020 Industrial Strategy announced actions to support the green and digital transition, but these transformations were affected by the crisis. New measures to support the green and digital transitions were outlined by the EC, among others:

- Developing jointly with EU countries, industry and stakeholders, transition pathways to identify the actions needed to achieve the twin transitions. These pathways should offer a better bottom-up understanding of the scale, cost and conditions of the required action to accompany the twin transitions for the most relevant ecosystems leading to an actionable plan in favour of sustainable competitiveness;
- Working with the countries to accelerate investments into renewables energies;
- Supporting recovery efforts and development of digital and green capacities under the Recovery and Resilience Facility and bringing together private and public funding to finance research and innovation on low-carbon technology and processes (through Horizon Europe partnerships);
- Investing to upskill and reskill to support the twin transitions.

The situation resulting from the COVID-19 has accelerated the process of digitisation, highlighting its strengths as well as its weaknesses. During this time, the capacity and resilience of telecommunications networks has become evident, consolidating digital audio-visual services as a mass consumer good, teleworking has significantly expanded, and the digitisation of education has received a boost. A key point to address the digital transition has been to guarantee the accessibility thereto of society as a whole and promoting the digitisation of business – in particular SMEs and start-ups – and industry, R&D&I, and digital training of the population.

According to a report by the International Telecommunications Union (2018), in OECD countries, an increase of 1% in the intensity of digitisation in the country represents an increase in GDP per capita of 0.14%.

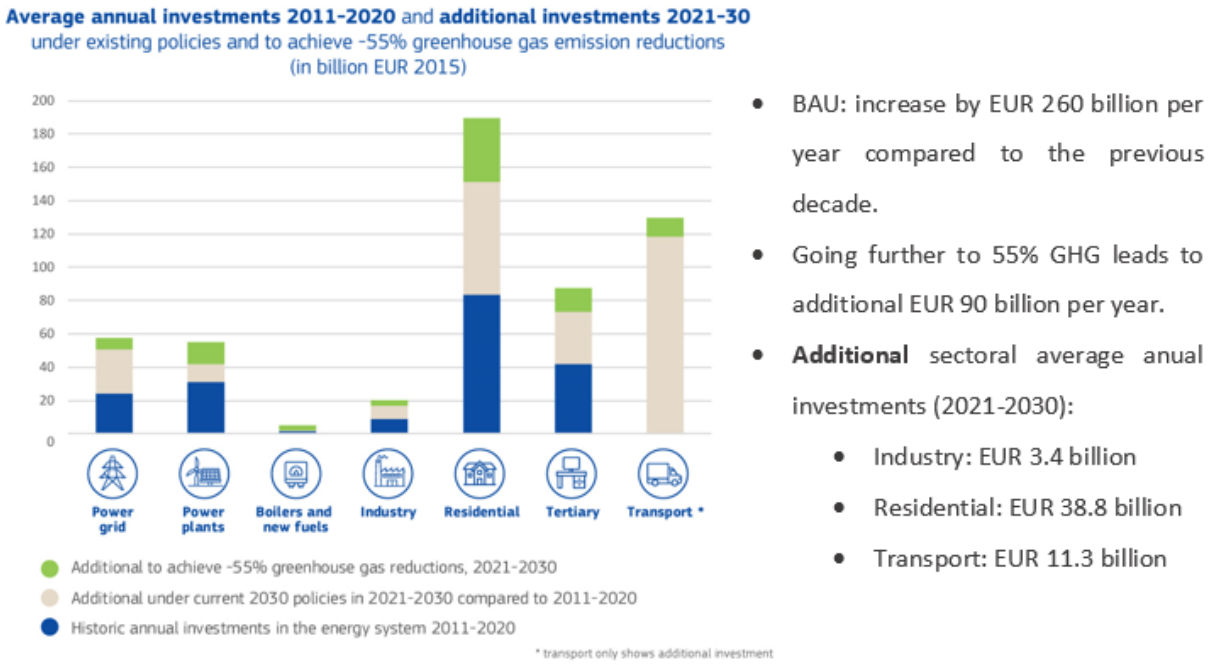


Figure 37 - Green Investments. Source: European Commission. DG GROW, 2021

To be successful in the green transition, EU industry requires:

- A coherent and stable regulatory framework;
- Access to capacities and infrastructure – Energy and Industry Geography Lab;
- Finance for innovation and deployment - HE, State Aid rules, renewed Sustainable Finance Strategy;
- Access to raw materials – European Raw Materials Alliance;
- Decarbonized energy – Support the uptake of corporate renewable power purchase agreements;
- The right skills – Skills Roundtables.

The health crisis caused by COVID-19 has highlighted the need to accelerate the ecological transition, as a key element in the reconstruction phase. Using the circular economy as advantage for industrial modernization also means to rethink of waste as resources – we have a finite capacity of natural resources and it is more necessary than ever to process /absorb waste, decrease pollution and develop new business models.

In the textile sector to modernize and improve industrial competitiveness, there is a need to incorporate and leverage the benefits of digitization and sustainability across our existing and future business fabric, favoring its energy transition and promoting cross-

cutting actions that foster the necessary transformations to guarantee its long-term viability. Furthermore, it is also necessary to promote a coherent digitalization plan for the entire value chain to fully leverage the synergies and opportunities of new technological developments and data management.

Digitization can also facilitate the management of information and the improvement of environmental knowledge and parameters, the integration and systematization of textile production processes, the modernization of management and the prevention of climate risks.

Creating textile supply chain transparency through digitization can boost both productivity and resilience.

The process for manufacturing should also be cleaner and more resources efficient (especially with regard to energy, water, raw materials), with associated innovations in products definition, usages (e.g. mobility of goods) and services. Regarding advanced manufacturing technologies, projects and innovations should be pushed on biomaterials, with ambition to boost re-use and recycling (especially for new materials such as composites). The techno-economic maturation of new solutions such as hydrogen or organic thin-film photovoltaic should also be accelerated. Furthermore, valorization of cross-fertilization of skills represents an innovation and growth potential for the territories.

Recovery plan and resilience: European financial instruments

Recovering from the COVID-19 crisis may require long periods of implementation, which will focus initially on rapid restoration of critical functions. However, these periods should also be used to cater to long-term mitigation and preparedness agendas to support build-back-better approaches (World Bank. 2020). In order to support the recovery, a comprehensive plan was discussed with the members' states and proposed at the European level.

The NextGenerationEU was created as a temporary instrument channeled through the EU's long-term budget. The €750 billion budget will be invested across several programs and will be distributed to EU countries and beneficiaries through grants (€390 billion) and loans (€360 billion) as depicted in the two illustrations below.

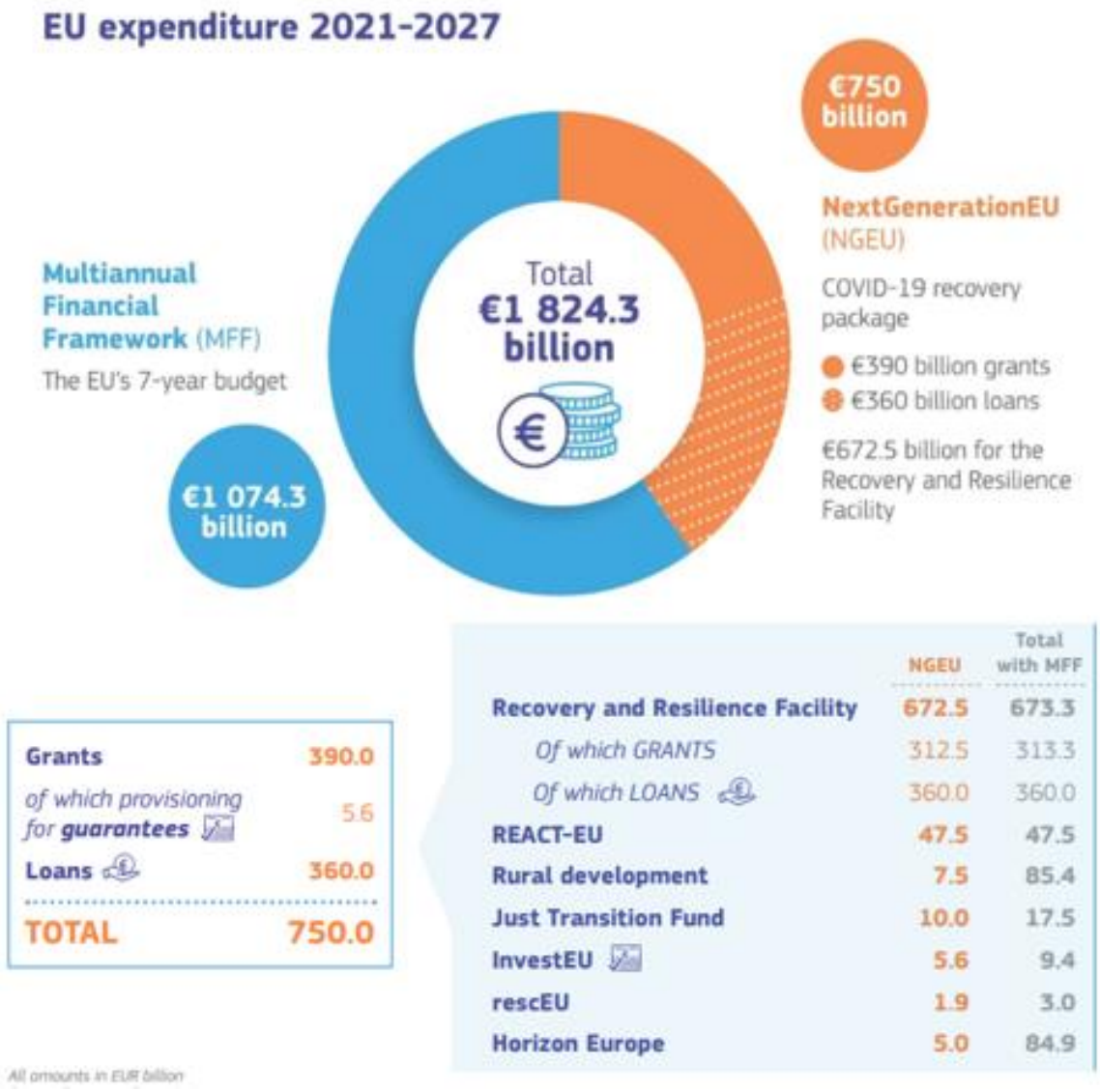


Figure 38 - NextGenerationEU budget repartition. Source: European Commission, 2021

The **Recovery and Resilience Facility (RRF)** will make available €672,5 billion to support reforms and investments made by the member states.

It consists of a large-scale financial support to public investments and areas such as green and digital projects. The objective is to reduce the economic and social impacts of the COVID-19 crisis while making European economies and society more sustainable and resilient to address the possible challenges regarding the ecological and digital transitions, and at the same time to be better prepared to seize the opportunities they may represent.

Figure 39 - Recovery and Resilience Facility budget structure. Source: European Commission, 2021

The grant component of the RRF is divided among EU countries and the support is conditioned by the submission by the EU countries of a national Recovery and Resilience Plan.

These national plans present how the member states will spend EU money. They explain the public investments and reforms to be engaged, taking in consideration the challenges identified in the European Semester and recommendations formulated per country. The twin transition objectives are important components, as a minimum of 37% of expenditures should be planned for climate investments and reforms and a minimum of 20% of expenditures to foster digital transition per country.

1. **Recovery Assistance for Cohesion and the Territories of Europe (REACT-EU)**

Another important financial instrument put in place in response to the COVID-19 crisis is **REACT-EU.** With a budget of €47.5 billion, the initiative that extends the crisis response will be made available through the structural funds:

- the European Regional Development Fund (ERDF)
- the European Social Fund (ESF)
- the European Fund for Aid to the Most Deprived (FEAD)

These funds will be provided in 2021-2022 (the credit should be used before end 2023) to guarantee a rapid respond and piloted by the regional authorities. These additional resources will be used to fund projects that foster crisis repair capacities, as well as investments in operations contributing to preparing a green, digital and resilient recovery of the economy and prepare for the industry of the future.
NextGenerationEU will also bring additional money to other European programs or funds such as Horizon2020, InvestEU, rural development or the Just Transition Fund (JTF).

5. CLUSTER ANALYSIS

ATEVAL - ASOCIASÓN TEXTIL DE LA COMUNIDAD VALENCIANA

Sector description with some indicators

The Valencian Textile Cluster is located in the Valencian central regions: L'Alcoià, El Comtat and La Vall d'Albaida, as well as other municipalities such as Crevillent, Castelló, Callosa de Segura and the metropolitan area of Valencia.

The Textile Cluster is combined by:

- Mainly SME due to the better adaptation of this type of company to the variations of the textile market and with the advantages that the geographical concentration itself brings, which favours the complementary relationships of the companies.
- The research institute (AITEX), universities, and textile training centres.
- Public administration and other bodies that provide support to the industry.

Figure 40 – Valencian region – L'Alcoià

The following table shows the profound impact of the COVID-19 pandemic in the Valencian Textile Sector with a significant contraction in GDP.

	2016	2017	2018	2019	2020	%20/19
Companies	1.379	1.424	1.501	1.484	1.481	**-0,2%**
Employment	22.780	23.188	23.290	22.814	21.709	**-4,8%**
Turnover (Mill€)	1.964	2.021	2.073	2.016	1.722	**-14,6%**
Exports (Mill€)	858	880	893	916	836	**-8,7%**
Imports (Mill€)	969	1.067	1.168	1.145	1.149	**-0,3%**
Balance of Trade (Mil	-111	-187	-275	-229	-313	**36,7%**

Figure 41 - Economic Data from the Valencian Textile Sector

Source: CITYC

In the short term, the vaccination process and the health situation are the main determinant of economic developments and growth forecasts for 2021. Another factor that will shape economic developments in the coming months is the extent to which

global financial stability is maintained and the evolution of the external sector, world markets and European demand.

The possible structural damage to the productive fabric and employment resulting from the long duration of the pandemic has yet to be assessed.

Growth and job creation over the period 2021-2024 will largely depend on the implementation of the Recovery, Transformation and Resilience Plan.

The pattern of growth that the Valencian economy will follow during the period 2021-2024 will be clearly guided by domestic demand, through the recovery of private consumption and the strong boost to investment from the Recovery Plan. The external sector, for its part, will contribute positively to growth in 2022, once tourism activity has normalised, and in 2024, when the stimulus from the Recovery Plan is withdrawn.

Cluster general description

ATEVAL is a private industrial association. It has more than 340 associated textile companies and represents almost 10.500 persons employed. ATEVAL has cooperated with various entities in European projects. It has human resources expert in coordinating European projects, in direction the work team for the dissemination and intellectual property rights. ATEVAL activity is divided into several departments: innovation, industry and environment, external promotion, training, labour and tax law. The association provides advice in all these fields. As well as information and training services in various areas covered.

ATEVAL is responsible for coordinating the actions of the CIE (Consejo Intertextil Español), carried out under the name of Home Textiles from Spain. To carry out its activities, it maintains a continuous contact and collaboration with other institutions and bodies of different areas such as the Institute of Foreign Trade (ICEX), the Valencian Institute of Export (IVEX), the various chambers of commerce of Valencia, the Textile Technology Institute (AITEX), the CEOE, COEPA, CIERVAL, CEV, etc. At European level, it participates in the European Textile Employers Manufacturers. In addition, ATEVAL has signed cooperation agreements with various entities, to increase the supply of services (European projects, processing aid administration, environment, new technologies, and promotion abroad).

ATEVAL in the last five years has participated in 12 financed projects by EU.

Mission

To promote and project the constant evolution of the companies through innovation, internationalisation and cooperation as the driving force behind competitiveness and the generation of new business opportunities.

Vision

To lead and boost the transformation process of the Valencian Textile Cluster, being a reference point as an entity that generates, promotes and manages innovation and internationalisation in the business world.

SWOT Analysis

ASSOCIACIÓ AGRUPACIÓ D'EMPRESES INNOVADORES TÈXTILS

Sector description with some indicators

In Catalunia, the advanced materials sector is composed by more than 750 companies, specialized in metal, polymers, ceramic and glasses, composts and processes, biomaterials, natural and textile materials.

The secotr's annual turnover accounts for approximately € 2.660 million and employs over 6.000 people.

From the sector's companies, 42% is specialized in polymers, 27% in textil materials, 12% in metal materials and 19% in other type of materials.

Over 65% of the advanced materials textile companies are small or micro companies, in the other hand, 11% are large companies.

The trends in the sector point that the Energy, Health and Environmental sectors are expanding and their needs for textile and advanced materials will be a good opportunity for the sector.

Furthermore, it is important to highlight that the sector will face many challenges in the coming years, namely, the lack of trained people in the sector, the high investment to address the advanced materials implementation, the costs and the difficulty of the Digitalization process, the R&D&I investment, the efforts to address the end-of-life problem of the textile products, the sustainability and the circular economy's goals to reduce waste and water consumption.

Cluster general description

AEI Tèxtils was born in 2008. It is a cluster with a non-profit association structure, formed by Catalan companies in the advanced textile materials' value chain and related organizations. AEI Tèxtils supports their innovative potential, setting up the advanced textile materials cluster of the region, to which the Textile Innovative Business Grouping gives legal status.

Its main objectives are to promote R&D+I, mainly in cooperation; to promote, at all levels, cooperation within the Catalan advanced textile materials sector and to promote the cluster and its members at international level.

The figure below illustrates AEI Tèxtils' structure: In the middle, as the core of the organization, there are the manufacturing companies, covering the whole value chain to produce advanced textile materials: from yarn producers, fabric manufacturers (knitting, weaving and nonwovens) to finishing companies.

Surrounding the center are the organizations that support these companies, such as raw materials suppliers, equipment suppliers, service providers, R&D centers, university or the public Administration.

The products manufactured by the cluster members, which can be intermediate or final, are focused on technical applications: civil engineering, agriculture and fishing, building and textile architecture, automotive and public transport, medical, hygienic and sanitary applications, packaging and goods transport, sports and leisure, personal protection, industrial uses, environmental protection, mainly.

Figure 42 - Structure of AEI Tèxtils

The cluster has 40 members, 33 of them are SMEs, other members are research institutes, technological centers, and other organizations related to the sector.

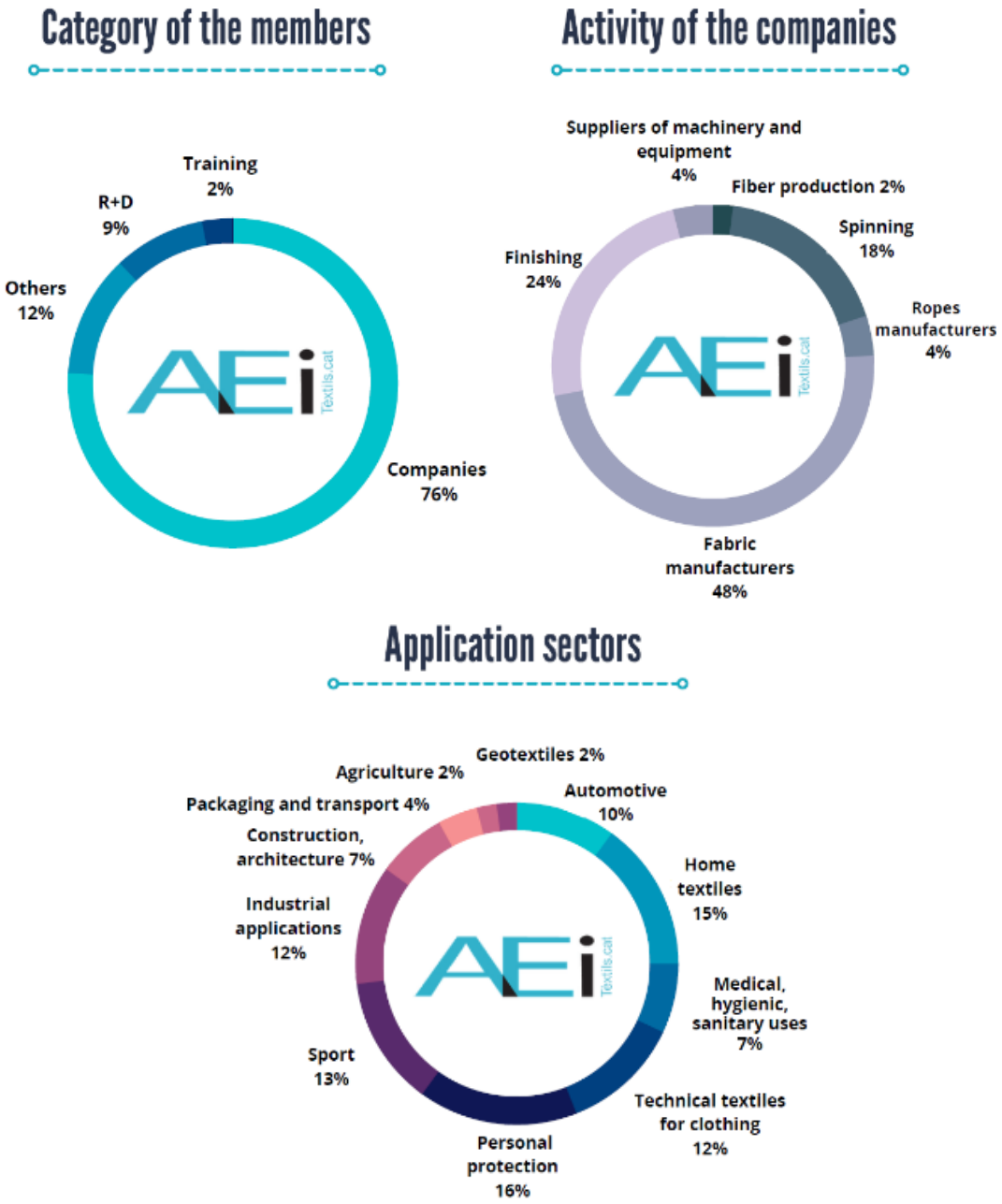


Figure 43 - Category, activity, and application sectors of the cluster members

Mission

To promote innovation as driver of improving the competitiveness of its members, in a close and personalized approach by fostering strategic collaborations.

Vision

To position the Catalan sector of advanced textile materials as a European benchmark in innovation, facilitating innovative practices that improve its competitiveness and international visibility.

Cluster SWOT analysis

S

- Strong know-how about the sector
- Good communication and interaction with members
- Strong industrial base
- Excellent project funding
- High degree of participation by members

W

- Limited number of members
- Members with limited size
- Members with resources to get the most out of the cluster
- Lack of joint visibility in trade fairs and internationally
- Low degree of joint developments among members

O

- Opportunities for collaboration among members
- Digitalization and Industry 4.0
- New business models
- Soaring of sustainability and circular economy
- New funding programs for textile
- Strong collaboration with other EU clusters
- Potential for growth in number of members

T

- Agressive cost-competition
- Atomized associations in the sector (guilds, trade unions, clusters, etc.)
- Fear of competition in the cluster
- Lack of infrastructure and funding opportunities to investment in new technology
- Lack of specific know-how in digital and green

PRODUTECH – ASSOCIAÇÃO PARA AS TECNOLOGIAS DE PRODUÇÃO SUSTENTÁVEL

Sector description with some indicators

The Portuguese production technologies sector has a considerable economic relevance and weight in the national manufacturing industry, mainly for the technological development and production capacity that it delivers to its clients and for its weight in terms of employment and industry turnover and gross added value.

The sector is mainly composed by micro and small companies, which have consistently registered an increasing turnover and financial autonomy over the years. In terms of geographic distribution, more than half of the companies in the sector are located in the North Region of Portugal, with the Centro Region coming second on the rank.

In 2015 the production technologies sector was responsible for 10% of the Gross Added Value (GAV) and for 8% of the Gross Fixed Capital Formation (GFCF) of the entire manufacturing industry. In average, the added value /production ratio is above 35%, considering all the companies of the sector. If we considered the machine and equipment producers only, in 2014 the investment in R&D was 4% higher than the GAV and the production technologies sector is the second most important sector regarding the Intellectual Property requests in the European Patent Office.

The production technologies sector exports half of its production and total exports have regularly increased over the past years. The main destination of the sector's exports is the European market, particularly Germany, Spain and France. The sector imports have slightly increased over the years and their main origin is also the European market, in particular Spain, Germany and Italy.

Cluster general description

PRODUTECH is officially recognized by the Portuguese Government as the management organization for the Production Technologies Cluster (National Cluster). The cluster's mission is to promote the sustainable development of the Production Technologies Industry and its client sectors, through the articulated cooperation between stakeholders, notably Industry's key players, R&D organizations and other entities, and by the implementation of strategic integrated projects, addressing innovation, cooperation and internationalisation. Its multi-annual action plan defines 4 strategic action vectors: (1) Growth, consolidation, qualification and strategic cooperation; (2) Visibility and internationalization (including the internationalization of R&D and

innovation sources and the industry participation at current and emergent global value chains); (3) Strategic Information and Intelligence; (4) R&D and Innovation.

PRODUTECH plays also an active role in several European initiatives and projects, such as Vanguard Initiative, in several working groups coordinated by the EC within the scope of the Action Plan for Digitising the European Industry, among several others, while participating in the nurturing and expanding the reach of the Production Technologies eco-system, within R&D, innovation and business development and in the establishment of cross cutting initiatives leveraging the adoption and diffusion of advanced and digital production technologies throughout the manufacturing industry. The Cluster currently has 112 associated organizations, of which 80 are companies, 23 R&D, education and training entities, 9 associations (encompassing industry sector, R&D sector and civic associations). Beyond the associated members and due to the direct participation of industry associations and sector oriented R&D organizations, the scope and reach of cluster activities and impact is considerably wider. Its cooperation links extend towards municipalities, venture capitalists, as well as it actively collaborates with regional authorities and national funding agencies, in the identification of stakeholders' needs, in the definition of policy priorities and in the implementation of projects and initiatives that address towards the defined priorities. PRODUTECH is member of the executive board of the partnership Portugal Clusters, gathering the majority of officially recognised Portuguese clusters.
PRODUTECH is the host organization of the PRODUTECH DIH national platform (national scope) and of iMan Norte Hub (regional scope).

Mission

To strengthen collective efficiency and strategic intelligence at the service of the expansion, enlargement and qualification of the Portuguese Production Technology Sector in highly dynamic and innovative areas, as well as to develop and promote its offer and image at national and international level.

Vision

Portugal, country of excellence in engineering, flexible, and integrated solutions, in the most dynamic and innovative production technologies.

SWOT Analysis

PORTUGUESE TEXTILE CLUSTER

Sector description with some indicators

The Portuguese Textile and Clothing Industry exports more than 5 billion euros annually to over 180 countries around the globe and is responsible for around 10% of all Portuguese exports of goods. The Portuguese balance of trade in textile and clothing creates a surplus of over 1 billion euros – making this one of the most important activities for the country´s economy.

The Portuguese Textile and Clothing (TCTC) Industry comprises over 6.100 corporations and a little more than 5.900 individual companies, employing in total about 132.000 direct workers and generating a turnover of 6,6 billion euros in 2020.

It is one of the most important Industries of the Portuguese economy, accounting for 9% of the national exports of goods, 18% of the manufacturing industry employment and 8% of the manufacturing industry turnover.

It is one of the activities with a positive trade balance of goods, registering often a balance of more than one billion euros. The Portuguese Textile and Clothing Industry is mainly located in the “Norte” region of Portugal which represents 87% of the sector’s turnover and 86% of employment, followed by the “Centro” region (11% of the turnover and of the employment).

The “Norte” region has the higher employment concentration when compared with other European Regions (EU-28).

The manufacture of outerwear, except for leather and workwear is the activity with higher turnover (38%), followed by manufacture of made-up textile articles, except clothing, among which home textiles are included (30%), by weaving (9%), and by finishing of textiles (7%).

Portugal is one of the most important European players in terms of textile and clothing industry. Strongly export-oriented, this industry has on EU markets its main destinations, with Spain representing over one third of total exports. USA is the main non-EU market destination, representing from 5% to 6% of the total textile and clothing Portuguese exports.

After a decline period generated by the global TC liberalization (2005) with the entry of new players in the world TC trade and the impact of the global economic and financial crisis (2008), with consumption disruptions in the most important Western markets, the Portuguese TC Industry began to recover in 2010.

It traced from there a sustained growth path, driven by a set of critical success factors that characterise this industry: industrial know-how, including design and product development, high quality of goods and services, flexibility, adaptability and great reactivity, a culture of business to business, specialized human resources with extensive experience and diverse skills, quick response ability, a wide range of high value-added services, strong innovation skills, complete, structured and dynamic textile and clothing pipeline.

All of these achievements were supported by consistent and developed competence centres, namely the TC specialised CITEVE (Technological Centre for Textile and Clothing Industry), CeNTI focused on Nanotechnology and Smart Materials and other R&D centres and Universities which have in their portfolio competences and background knowledge relevant and for the new challenges of TC industry for the upcoming years.

Cluster general description

Founded by 60 members (45 companies + 1 start-up and 14 non-business entities), the Textile Cluster is a platform where entities establish win-win relationships, with the ultimate objective of producing and sharing knowledge as a support for innovation and competitiveness. Portuguese Textile Cluster is officially recognized by the Portuguese Government, as the entity responsible for managing and promoting the development, innovation and competitiveness of the Textile and Clothing value chain acting as:

- Strategy influencer and roadmaping;
- Bridge for the definition of industrial policies and smart specialisation strategy (Regional, National and European);
- Tool for economic development, to seed innovation, competitiveness and new business models enabler.

The Portuguese Textile Cluster is also a sectoral support structure with the purpose of stimulating processes of interaction, articulation, collaboration and information sharing within the economic aggregate itself, acting in a way that is supplementary to the performance of its own as an instrument of obtaining increments of competitiveness for innovation and internationalization, in a logic of collective efficiency.

Mission

To enhance the endogenous capacity of the consolidated economic aggregate around the textile business. Increase business competitiveness through co-operative innovation:

Promoting and facilitate an integrated and sustainable development of the textile value chain.

Stimulating a strong coordination between the different actors of the cluster and stimulating the approach of the cluster to complementary and strategic value chains.

Vision

The Portuguese Textile Cluster VISION is to be one of the most competitive in the world in the research, design, development, manufacture and marketing of textile and clothing products, aimed at the fashion, home, technical and functional textiles segments.

SWOT ANALYSIS

POLE EMC2

Sector description with some indicators

The Pays de la Loire region includes 5 geographical departments (Loire-Atlantique, Maine-et-Loire, Mayenne, Sarthe and Vendée). It constitutes 5,8 % of the country surface with 3.8 million inhabitants. Pays de la Loire is a very industrial region counting with a lot of manufacturing sites in particular from the key economic sectors such as agri-food, metallurgy, machinery manufacturing, transport materials, plastics processing and rubber, fashion industry (textile, closing, leather, shoes, leatherwork), wood industry (manufacture of furniture), but also aircraft construction and shipbuilding. Industry and manufacturing play a key role in the regional economy. Accounting for 16.2% of jobs, the industry is more significant in Pays de la Loire than at the national level (11.7%), making it the second most important region for the share of industrial jobs[46].

Cluster general description

EMC2 is a French competitiveness cluster created in 2005 in the framework of a national initiative for industry competitiveness, operating in the Pays de la Loire and Brittany regions on Advanced Manufacturing Technologies. The association gathers all the actors of innovation around key markets and technologies to foster the emergence of collaborative R&D projects. The vision of the cluster is to promote business development through collaborative innovation, building an innovation path mixing skills, markets and technologies to make innovation R&D projects emerge.

EMC2 leads a network of 396 members composed of SMEs, Large Enterprises (LEs) such as Airbus, Chantier de l'atlantique, Naval Group, General Electrics, Dassault… as

[46] https://www.paysdelaloire-eco.fr/ressources-analyses/industrie/

well as the Research & Technical Organisations of the territory (Ecole Centrale de Nantes, Université de Nantes, Ecole des Mines de Nantes,...).

EMC2 as the European manufacturing technology cluster provides expertise and brings together a community to ensure factories future successes, promotes collaborative innovation among SMEs in its territory and industrial sectors and integrates digital, human and environmental issues to promote competitiveness.

Since 2005, EMC2 accredited 650 projects of which 349 received funding ranging from 100 k€ to 300 M€ (data of 31.12.2020). It represents 1.69 M€ funding of which 748 M€ from public funds. For the period 2014 – 2020, 101 EU projects were supported by EMC2 with 33 awarded (with a success rate of 32,5%).

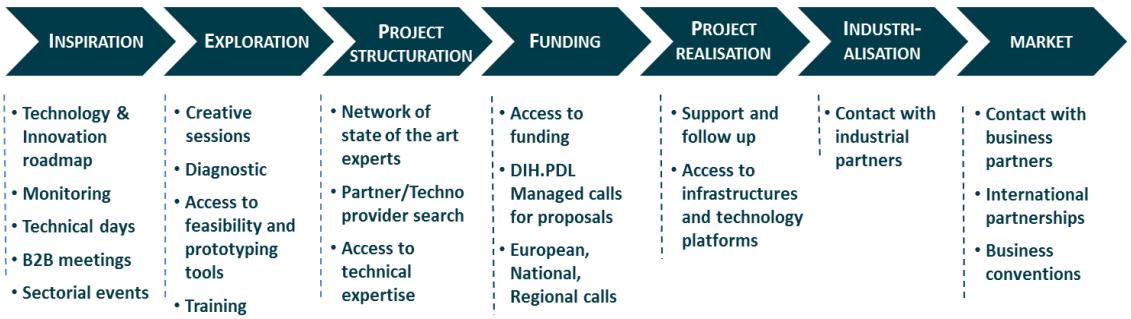
EMC2 is also registered as Digital Innovation Hub (DIH) and is recognised for its capacity to support industrial SMEs into developing and integrating digital solution and support technology providers SMEs to develop new solutions. In order to enlarge its services and continue to improve the support provided to the regional ecosystem, in line with the RSI3 strategy, EMC2 co-lead in 2021 the preparation of the future regional European Digital Hub (EDIH DIVA) to gain further visibility at European level and provide additional technological resources to its members.

Mission

EMC2 mission is to accelerate the development of its territory and members (industrial and academia) through collaborative innovation.

Vision

The ambition of the EMC2 cluster is to make its territory a world-wide reference for advanced manufacturing; through a collaborative and multi-market approach, based on open innovation for the future of factories.



SWOT Analysis

CLAMTEX PARTNERSHIP SWOT ANALYSIS

Based in the SWOT analysis of each cluster and the information collected, a collective analysis of the cluster was made and presented below. This collective analysis aims to assess the strengths and weaknesses of the group, in order to identify and maximize potential synergies for the future.

From the overall analysis of both individual and partnership SWOT we may conclude:

- Some obstacles identified individually, like the lack of digital skills or small business companies, predict that there is still a long run to cover until reaching the needed digital transition in Textile and Clothing Sector;
- Most of the SME's that are part of the CLAMTEX Cluster ecosystem, don't have the needed maturity concerning to industry 4.0 and, allied to this, still little cross-sectoral collaboration;
- CLAMTEX partnership has a strong ecosystem, both in Textile Clothing and Advanced Manufacturing with strong digital know-how, with high level skills in fashion and technical textiles industry allowing a better intersectoral collaboration;
- A dedicated programme combining three main domains: Public Funding, Skills Uptake and Technological Diagnostic Tools, towards the implementation of

Advanced Manufacturing capabilities in Textile & Clothing Industry, would favour the uptake of new emergining technologies in the manufacturing and business operations;

- Companies able to supply advanced manufacturing systems and technologies should be more integrated in the Textile and Clothing value chain pushing for the adoption of new emerging technologies in this industry;
- In order to reduce the costs related to the adoption of Advanced Manufacturing Systems in SMEs, CLAMTEX partnership is in a perfect position to push for the creation of “tech offer marketplace” were suppliers and clients could meet and link the tech offer with the companies needs;
- CLAMTEX partners could act as the innovation test bed representative in each of the partners countries, showcasing a pilot line with recent and relevant advanced manufacturing technologies provided by tech manufacturing suppliers, where textile and clothing companies could test and validate several tech offers in the same space;
- The decline of the mass consumption textiles and clothing model should be seen as an opportunity to create more sustainable businesses, investing in greener products and new ways of doing business, namely online business with the support of novel digitalization technologies;
- The transformation in manufacturing will allow Textile & Clothing responding to a ever changing global environement, focusing on customer needs, producing faster and low-energy consumption products, helping companies to become more competitive in the market;
- CLAMTEX partnership is a strong ecosystem to enable cross-sectoral collaboration, regional and international partnerships, and joint activities enabeling SMEs competiteviness in Europe and creating a more resilente Europe landscape.

CONCLUSIONS

After the development of the study, it is possible to list some trends that will be useful, if not essential, to guide the path of the Textile Industry in the coming years.

First, it is undeniable that the COVID-19 pandemic alerted to the need and urgency to transform the sector, with a view to Sustainability, Circular Economy and Digitalization.

Furthermore, the climate emergency has made it clear that the way the sector has been operating is no longer viable or sustainable. In this sense, it is urgent to stop and reverse the damage associated with the Textile Industry as soon as possible. To this end, efforts must be made to transform the manufacturing processes, the materials used and the business models themselves, in order to promote Sustainability and Circular Economy.

The new technologies associated with Industry 4.0, namely, big data, the Internet of things, augmented reality, virtual reality, 3D printing, among others, will be excellent tools, whose adoption will certainly promote the transformation of the sector.

With regard to industry trends in terms of products, technical textiles are a growing segment and Europe has good conditions to compete for leadership in this field.

Beyond that, after analyzing the global value chain, we identified a gap in the "End-of-life" hotspot, which illustrates the inexistence of circular economies in this field. In this way, this “hotspot” can constitute a good business opportunity for European SMEs, as they can explore the added value of discarded textile products, which are easily accessible, and close the life cycle of the products in a profitable way.

In line with the European Union's strategic objectives, the transformation of the Textile Industry will contribute to its recovery and will increase the sector's resilience to new global dynamics, as it will make it less dependent on external resources and more efficient. To this end, companies should also take advantage of the forthcoming Multi Financial Framework of the European Union to promote their transformation, because, beyond the financing facilities, they will become more competitive.

It is important that the transformation of the sector is not approached individually, as a collective approach will make it easier to take advantage of the competitive advantages of each partner and maximize potential synergies.

Finally, it is important to mention that the cross-sectorial and cross-regional collaboration will be a facilitator in the sector’s transformation process. First, because it increases the probability of success. Secound, it disperses and shares the risk. In third, it allows the sharing of knowledge and the creation of synergies.

RELEVANT DOCUMENTS

BCSD. (2018). Sinergias Circulares- Desafios para Portugal.

Blok, K., Hoogzaad, J., Ramkumar, S., Ridley, A., Srivastav, P., Tan, I., Terlouw, W., & Wit, M. de. (2016). Implementing circular economy globally makes Paris targets achievable. In Circle Economy; Ecofys.

COM(2020) 102 final " A new Industrial Strategy for Europe" https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0102&from=FR

Commission, E. (2021). Industry 5.0-Towards a sustainable, human- centric and resilient European industry. https://doi.org/10.2777/308407

Communication "Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery ", EC, 05 May 2021

Ellen MacArthur Foundation. (2020c). The circular economy : a transformative Covid-19 recovery strategy How policymakers can pave the way.

Ellen MacArthur Foundation. (2015). Growth within: a circular economy vision for a competitive Europe. Ellen MacArthur Foundation, 100.

Ellen MacArthur Foundation. (2019). Complete the picture: How the circular economy tackles climate change. In Ellen MacArthur Foundation (Issue September). www.ellenmacarthurfoundation.org/publications

Ellen MacArthur Foundation. (2020a). Circular economy and the Covid-19 recovery. www.ellenmacarthurfoundation.org

Ellen MacArthur Foundation. (2020b). Financing the circular economy: Capturing the opportunity. 102. https://www.ellenmacarthurfoundation.org/publications/financing-the-circular-economy-capturing-theopportunity%0Ahttps://www.ellenmacarthurfoundation.org/assets/downloads/Financing-the-circular-economy.pdf

European Commission. (2019). The European Green Deal. In European Commission (Vol. 53, Issue 9). https://doi.org/10.1017/CBO9781107415324.004

European Commission. (2020a). A new Circular Economy Action Plan For a cleaner and more competitive Europe. In The Cinema of Alexander Sokurov. https://doi.org/10.7312/columbia/9780231167352.003.0015

European Commission. (2020b). Leading the way to a global circular economy: state of play and outlook EN. In Journal of Chemical Information and Modeling (Vol. 53, Issue 9).

European Resource Efficiency Knowledge Centre. (2019). The implementation of the circular economy in Europe. Perspectives of EU industry cluster managers and regional policymakers. https://doi.org/10.2826/81623

Ganzarain, J., & Errasti, N. (2016). Three stage maturity model in SME's towards industry 4.0. Journal of Industrial Engineering and Management, 9(5), 1119– 1128. https://doi.org/10.3926/jiem.2073

Gower, R., & Schröder, P. (2016). Virtuous circle: How the circular economy can create jobs and save lives in low and middle-income countries. In Tearfund (Issue August). http://en.wikipedia.org/wiki/Virtuous_circle_and_vicious_circle https://es.weforum.org/reports/building-block-chain-for-a-better-planet

Ibn-Mohammed, T., Mustapha, K. B., Godsell, J., Adamu, Z., Babatunde, K. A., Akintade, D. D., Acquaye, A., Fujii, H., Ndiaye, M. M., Yamoah, F. A., & Koh, S. C. L. (2020). A critical review of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies. Resources, Conservation and Recycling, 164(May 2020), 105169. https://doi.org/10.1016/j.resconrec.2020.105169

IPCC. (2018). Chapter 3: Impacts of 1.5°C global warming on natural and human systems. In: Global Warming of 1.5 °C. An IPCC special report on the impacts of global warming of 1.5 °C above preindustrial levels and related global greenhouse gas emission pathways [...]. Special Report, Intergovernmental Panel on Climate Change, ISBN 978-92-9169-151-7, 175–311.

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse- Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence from the European Union (EU). Ecological Economics, 150(April), 264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028

Lopes de Sousa Jabbour, A. B., Jabbour, C. J. C., Godinho Filho, M., & Roubaud, D. (2018). Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. Annals of Operations Research, 270(1–2), 273–286. https://doi.org/10.1007/s10479-018-2772-8

Maslarić, M., Nikoličić, S., & Mirčetić, D. (2016). Logistics Response to the Industry 4.0: The Physical Internet. Open Engineering, 6(1), 511–517. https://doi.org/10.1515/eng-2016-0073

OECD. (2020). Improving resource efficiency and the circularity of economies for a greener world (Issue 20). https://www.oecd-ilibrary.org/environment/improving-resource-efficiency-and-the-circularity-ofeconomies-for-a-greener-world_1b38a38f-en

Pagoropoulos, A., Pigosso, D. C. A., & McAloone, T. C. (2017). The Emergent Role of Digital Technologies in the Circular Economy: A Review. Procedia CIRP, 64, 19–24. https://doi.org/10.1016/j.procir.2017.02.047

Portugal, G. de. (2014). Estratégia de Investigação e Inovação para uma Especialização Inteligente (EI&I). https://www.ani.pt/media/5238/enei- 2014.pdf

Quint, F., Sebastian, K., & Gorecky, D. (2015). A Mixed-reality Learning Environment. Procedia Computer Science, 75(Vare), 43–48. https://doi.org/10.1016/j.procs.2015.12.199

Ramalho, F. R., Barros, A. C., & Soares, A. L. (2017). NICHOS-OPORTUNIDADE PARA A FILEIRA DAS TECNOLOGIAS DE PRODUÇÃO: Novos Modelos de Negócio, Serviços e Produtos no contexto da Indústria 4.0.

Reflow. (2019). From Linear to Regenerative. https://fabcity.gitbook.io/handbook/

Ritzén, S., & Sandström, G. Ö. (2017). Barriers to the Circular Economy - Integration of Perspectives and Domains. Procedia CIRP, 64, 7–12. https://doi.org/10.1016/j.procir.2017.03.005

Sommer, K. H. (2020). Study and portfolio review of the projects on industrial symbiosis in DG Research and Innovation : Findings and recommendations. https://doi.org/10.2777/381211

Trusts, T. P. C., & Systemiq. (2020). Breaking the Plastic Wave: A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution.

Word Economic Forum. (2018). Building Block(chain)s for a Better Planet - Fourth Industrial Revolution for the Earth Series. Weforum.Org, September. http://www3.weforum.org/docs/WEF_Building-Blockchains.pdf%0A

World Economic Forum. (2016). The Global Risks Report 2016 11th Edition. 103.

World Economic Forum. (2018). Harnessing the Fourth Industrial Revolution for the Circular Economy. World Economic Forum, January, 1–29. http://www.weforum.org